SCHOOL SCIENCE AND MATHEMATICS

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FOUR NEW COMMITTEES TO SERVE YOU

At the time of the 1938 convention of the Central Association of Science and Mathematics Teachers, a progressive Resolutions Committee recommended to a Board of Directors that it authorize the president to appoint certain new committees. The Board approved the resolutions. These committees are now appointed and at work.

One of these committees is known as the Cooperation Committee. Through it, the Central Association will offer to cooperate with other organizations in the Central States which have as their purpose the furtherance of the interests of science and mathematics. The committee will welcome, I feel sure, suggestions from the membership as to where small organizations of this kind exist and what representatives should be contacted. Mr. Ira C. Davis, University High School, Madison, Wisconsin, is chairman of this committee.

A second of the new committees is the Curriculum Committee. This committee will not attempt to build or revise a curriculum. It will act more as a clearing house to make available to members of the Central Association and others who request it, information concerning experiments and studies pertaining to curriculum adjustments in the fields of science and mathematics. No doubt, much time and effort of both pupils and teachers is often wasted in curriculum revision attempts. We hope the efforts of our committee may be of some assistance to those who desire to correct this situation. Members of the committee will very shortly call on you for information. Please help them! Then watch for the announcement that they are ready to assist you. Mr. Walter H. Carnahan, Shortridge High School, Indianapolis, is chairman.

It was not the intention of those who recommended the appointment of a Research Committee, that the committee itself attack any great research problem. It is rather to serve as an agency to give credit and publicity to the results of research problems and to encourage research activity. Such problems will be limited at the present time to those dealing with the organization of subject matter and methods of instruction.

The purpose of the Instructional Materials Committee is to list visual and audic aids available for the instruction of mathematics and science with an evaluation and classification of them. Information on materials of this kind was given at each section meeting last year. This committee will attempt to bring and keep this information up to date. Mr. Harold G. McMullen is chairman of the committee.

All the above mentioned committees will report at the annual convention, December 1 and 2, at the Morrison Hotel, Chicago. Watch the pages of this journal for preliminary announcements about our Association Program and the Exhibitors Program for that meeting.

MRS. MARIE S. WILCOX
President

NATIONAL SCIENCE COMMITTEE AT WORK

HAROLD H. METCALF

On February 23 and 24, a NATIONAL SCIENCE COMMITTEE initiated by the Department of Science Instruction of the National Education Association met in Cleveland, Ohio. The purpose of the Committee is to develop a workable, worthwhile program in science instruction in grades one through fourteen. The study will probably require at least two years, and will need the concerted action of a large number of teachers representing all parts of the United States and all organizations interested in science teaching.

To initiate the study at Cleveland, each committee member, at the request of Mr. Ira Davis, General Chairman, presented a plan for developing a sound program of science instruction. Each plan was discussed by the various members and by the consultants. Experts on the teaching of conservation, geography, and health presented their views. Mr. W. E. Givens, Executive Secretary of the N.E.A. told of the work of the National Policies Commission and answered questions regarding the work of the committee. After two days of intensive study, a plan was evolved to break the problem into five fields, and a committee of consultants and members was appointed in each field to study and make a report of progress at the next meeting to be held in Cleveland on May 12 and 13, 1939. The five fields and committee chairmen are as follows:

"A philosophy of science teaching to be used as a form of reference,"—Nathan Neal of James Ford Rhodes H. S. in Cleveland, Chairman.

"What is to be taught in science to satisfy human needs?"—W. C. Croxton, State Teachers College, St Cloud, Minnesota, Chairman.

"Evaluation of what good teaching is and what good teachers are doing," —C. E. Preston, Associate Professor of Science Teaching, University of North Carolina, Chapel Hill, North Carolina, Chairman.

"The training of teachers for science instruction,"—S. Ralph Powers, Professor of Natural Sciences, Teachers' College, Columbia University, New York City, Chairman.

"The administration of the program of science instruction,"—Ira Davis, Associate Professor in Science Teaching, University of Wisconsin, Madison, Wisconsin, Chairman.

The problem of developing a workable, worthwhile program in science for grades one through fourteen offers a real challenge to every alert science teacher in the country. Possibly you have a teaching device, a method, a knowledge of student needs, or the results of a piece of research which you would like to share with other science teachers. If so, get in touch immediately with one of the chairman listed above.

Approximately one hundred consultants from various parts of the country are cooperating in the study. The seven national organizations of science teachers which have agreed to cooperate and their representatives on the committee are listed below:

Membership of National Science Committee

American Association For The Advancement of Science

Nathan A. Neal—Head of Science Department, James Ford Rhodes High School, Cleveland, Ohio.

Hanor A. Webb—Chairman, Division of Science and Mathematics, George Peabody College for Teachers, Nashville, Tennessee.

American Chemical Society—Chemical Education Section

Martin V. McGill—Chairman, Curriculum Revision Committee, Chemical Education Section, Lorain High School, Lorain, Ohio.

American Nature Study Society

Carroll Lane Fenton—Author and Producer of "Science Everywhere," a broadcast of the Blue Network of the National Broadcasting Company, 3000 39th Street, N.W., Washington, D. C.

American Science Teachers Association

Harry A. Carpenter—Supervisor of Science, Public School, Rochester, New York.

Central Association of Science and Mathematics Teachers

Harold H. Metcalf—Teacher of Chemistry and Assistant Dean of Junior Boys, Oak Park-River Forest Township High School, Oak Park, Illinois.

National Association for Research In Science Teaching

Ellsworth S. Obourn—Head of the Science Department, John Burroughs School, Clayton, Missouri. At New York University this year.

National Council on Elementary Science

Florence G. Billing—Supervisor of Science in the Elementary Schools of Detroit and Associate Professor of Science Education, Wayne University, Detroit, Michigan.

Department of Science Instruction, National Education Association

W. C. Croxton—Professor of Biology, State Teachers College, St. Cloud, Minnesota.

Mrs. Gladys F. Potter—Assistant Chief, Division of Elementary Education, State Department of Education, Sacramento, California.

C. E. Preston—Associate Professor of the Teaching of Science, University of North Carolina, Chapel Hill, North Carolina.

S. Ralph Powers—Professor of Natural Sciences, Teachers College, Columbia University, New York City, N. Y.
W. R. Teeters—Supervisor of the Biological and Physical Sciences, Board of Education, St. Louis, Missouri.
Ira C. Davis—Associate Professor in the Teaching of Science, University of Wisconsin, Madison, Wisconsin. Chairman.

THE NATIONAL COMMISSION ON COOPERATIVE CURRICULUM PLANNING

Mr. Walter Carnahan, Head of the Mathematics Department, Shortridge High School, Indianapolis, represented the Central Association at a conference called by the National Council of Teachers of English to consider secondary school curricula. Representatives of nine other national organizations were present. The assembled group chose the name, *The National Commission on Cooperative Curriculum Planning*, and will continue its studies over a period of years. This meeting was held in Detroit.

THE SIXTY TEXTBOOKS OF 1939

The First Annual Exhibition of Textbooks under the sponsorship of the Textbook Clinic of The American Institute of Graphic Arts will be opened to the public on May 23rd at the Public Library, New York City, and will continue until June 3rd. An advance opening for members and exhibitors will be held on the evening of May 22nd.

The Exhibition will consist of sixty books, chosen by a jury of five people on a basis of artistic and technical excellence and of suitability—as far as format is concerned—to instructional purposes. The value of the literary content will not be considered.

All publishers of textbooks have been invited to submit books. In order to be eligible, books offered for consideration must have been published between March 1, 1937 and March 15, 1939, and must have been designed and manufactured in the United States or Canada. Workbooks and books for supplementary reading will be considered if planned primarily for school use.

After the opening in New York, the Exhibition in duplicate will be sent on tour to various places throughout the United States. Educators are showing a steadily increasing desire for well designed books; so there is no doubt that the Exhibition will arouse interest wherever it goes.

The committee from the Textbook Clinic that has made arrangements for the Exhibition includes the following members: Ernest Hesse, Treasurer of the World Book Company, *Chairman;* Frederic G. Melcher, Editor of the *Publisher's Weekly;* J. Kendrick Noble, President of Noble and Noble, Publishers; Arthur R. Thompson, Chairman of the Textbook Clinic (*ex officio*); Carl Van Ness, Appleton-Century Company; Alicia F. Yasinski, The Macmillan Company.

The jury of five that will select the sixty books includes Jean Ayer, educator and author of textbooks; John A. Begg, designer—especially distinguished for his work in the textbook field; William Jansen, Assistant Superintendent of the Schools of the City of New York; E. W. Palmer, President of the Kingsport Press, Kingsport, Tennessee; and S. Spencer Scott, Director of the Educational Department, Harcourt, Brace and Company.

THE FUNCTION OF BIOLOGY IN GENERAL EDUCATION

R. C. Gilmore
Wright Junior College, Chicago, Illinois

In an attempt to consider the function of biology in the program of general education, one must first perhaps venture into the rather dangerous field of defining the objectives of general education as contrasted with more specialized aspects, as professional and technical education. The objectives of education have been defined many times and by many people. From the well-known "Cardinal Principles" of 1918[1] to the most recent issues of the educational journals one finds restatements—in varying terms and with different emphases, it is true—of such general objectives as (1) personal health, (2) worthy home membership, (3) desirable citizenship, (4) desirable social relationships, (5) worthy use of leisure time, (6) ethical character or ethical standards, (7) life enrichment, etc., etc.

Perhaps the most significant recent statement of the functions of general education is that of the Committee on the Function of Science in General Education of the Progressive Education Association. In the words of the committee, "the purpose of general education is to meet the needs of individuals in the basic aspects of living in such way as to promote the fullest possible realization of personal potentialities and the most effective participation in a democratic society."[2]

Note that the emphasis is on ***needs of individuals***. Needs are considered by the committee in both their personal and social aspects; i.e., in the light of the satisfaction of a personal "want (biological tension) or a desire on the one hand, and the requirements, demands, and standards of social living on the other."[3] The needs of individuals can be classified "in terms of four basic aspects of living: (1) Personal Living; (2) Immediate Personal-Social Relationships; (3) Social-Civic Relationships; and (4) Economic Relationships."[4]

In the area of personal living are listed the needs of the in-

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[1] Commission on the Reorganization of Secondary Schools, Nat. Ed. Assn. ***Cardinal Principles of Secondary Education***, Bull. U. S. Bur. Ed. No. 35, 1918.

[2] Committee on the Function of Science in Secondary Education, ***Science in General Education***, p. 23. D. Appleton-Century Co. 1938.

[3] *Ibid.*, p. 25.

[4] *Ibid.*, p. 27.

dividual (1) for personal health, (2) for self assurance, (3) for a satisfying world picture and a workable philosophy of life, (4) for a range of personal interests, and (5) for esthetic satisfactions.[5] In the area of immediate personal-social relationships lie the needs for (1) "increasingly mature relationships in home and family life, and with adults outside the family," and (2) "successful and increasingly mature relationships with age mates of both sexes."[6] In the area of social-civic relationships one finds (1) "the need for responsible participation in socially significant activities," and (2) "the need for social recognition."[7] Finally, the needs for (1) "emotional assurance of progress toward adult status," (2) "guidance in choosing an occupation and for vocational preparation," (3) "wise selection and use of goods and services," and (4) "effective action in solving basic economic problems"[8] are found in the area of economic relationships.

If one grants that the previously-listed needs are applicable to the student at the junior college level, the question is then raised as to what part biology may play in their fulfillment. A complete, point by point discussion would be beyond the scope of this paper. Moreover, the subject has been exhaustively treated in the afore-mentioned committee report (of some five to six hundred pages!). However, it may be of some interest to point out how some of these needs are met, in the opinion of the author, by the survey course in biology of the Chicago City Junior Colleges, and to suggest others that are at best inadequately met, or in which the need can be better met in other fields of general education.

Lack of time prevents consideration of all of the areas of student needs. Hence the present paper will be confined to a discussion of the functions of biology in the first of the areas mentioned, that of personal living.

The health objective in personal living is emphasized throughout the entire first semester of the survey course. This semester is devoted largely to human physiology and hygiene. Anatomy and physiology are regarded chiefly as means of gaining an understanding of scientific bases for health rules and practices. Diet, posture, exercise, rest, the misuse of widely-advertised patent-medicine cure-alls and cosmetic glorifiers, the causes for

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[5] *Ibid.*, p. 64.
[6] *Ibid.*, p. 144.
[7] *Ibid.*, p. 188.
[8] *Ibid.*, p. 240.

and prevention of disease, the normal functioning of the various organ systems and the recognition of the more common or more dangerous malfunctionings, are among the topics covered. The student is made aware of the fact that the most logical and effective way of deriving benefit from the vitamin content and skin foods in popular soaps and cold creams is through eating the products containing them. The limitations and dangers of self-diagnosis and self-treatment, and the need for properly trained medical and dental advisers are made clear.

Opportunities for gaining self-assurance are perhaps limited to the banishment of baseless fears about personal health, sex relationships, etc.; the understanding of normal mental functioning and of mental hygiene; the recognition of the normalcy of variation and mental and physical capacities, that is, of the fact that in a typical population not every one can be nor should be expected to be either an Apollo or a Hercules, a Roosevelt or an Einstein. Opportunities for gaining in self-assurance might well be extended by greater provision for student participation in the preparation of exhibits for the demonstration laboratory, in fact-finding studies of food and health needs, etc.

The student is assisted in gaining a world picture and a philosophy of life by the understanding which he gains of man's place in the universe and of his relationships to the rest of the organic world. The picture of an evolving world is unfolded before him. The possibilities and the limitations of the scientific method in the control of man's environment are presented. The lack of biological evidence of racial superiorities is disclosed. The possibilities of human improvement through eugenics are suggested.

The range of interest of the student is extended through the opening of new vistas of microscopic and macroscopic life. Numerous problems arise, for the solution or further study of which the student is referred to the demonstration laboratory or to supplementary readings. This phase of activity might be extended by greater use of the demonstration laboratory as a student project workshop, by the establishment of a well-rounded departmental library, by well-planned field trips to museums, zoos, forest and field, research laboratories where biological principles are being evolved and to commercial establishments where biological principles are being put to practical uses.

The average biologist's conception of esthetics is probably

rather narrowly limited to the appreciations of sculpture, paintings, literature, music, the roseate sunset or the delicate orchid. In this restricted sense, the field of esthetics is largely untouched by the survey course, as I believe is true of most college science courses. One hears much and sees little of the anticipated "appreciations of the beauties of Nature" derived from discussions of the classification of the plant kingdom or from demonstrations of the internal anatomy of the earthworm. In the larger and truer sense of the committee report, however, esthetic appreciations are to be gained from such activities as fine workmanship in the preparation of reports, the achievement of originality and creativeness in the laboratory, the appreciation of orderly form and development in the living world, as well as from the beauties of natural things. Here again field trips and well-planned laboratory demonstrations could be of major assistance. Certainly a considerable number of our students get an esthetic "kick" out of such purely passive "activities"(?) as observation of the laboratory terraria, the marine aquarium, etc.

To assume that the suggested contributions of the biology survey course to the needs of the student in the area of personal living have actually met these needs in a considerable proportion of the student body would be wishful thinking to a rather high degree. However, one hopes that the recognition of these needs as a problem and a challenge, and the suggestions of the various ways in which some contributions, however slight, have been made will prove to be a stimulus to further progress.

THOUSANDS TRAIN FOR VOCATIONS IN AVIATION

Under the policies of the Federal Government to provide financial assistance to vocational education in the States, more than 7,000 young men in different parts of the country are now receiving training which will prepare them to become aviation mechanics.

Figures issued by the Office of Education, Department of the Interior, show that in Federally aided vocational schools and classes throughout the United States, there are 2,182 such students in day-time classes, 3,242 in part-time classes and 1,653 in evening trade-extension classes.

The rapid expansion of commercial aviation has opened up a new field of activity for many boys. While the average boy is lured by the romance and adventure of piloting a great transport plane, there is a better chance of his finding an outlet for his mechanical ability in the specialized work that is needed at the airports, Commissioner Studebaker said. A far larger number of men are required for ground work than for pilot duty.

FUNCTIONAL OUTCOMES AND PURPOSEFUL ACTIVITIES IN ELEMENTARY SCIENCE

W. C. CROXTON
State Teachers College, St. Cloud, Minnesota

In an article in the November, 1937, issue of the elementary science journal, *NCES News Notes*, entitled, "Functional Outcomes of Science Teaching in the Elementary School," a group of teachers[1] reported a suggested list of desired outcomes. The brief discussion preceding that list expressed the viewpoint of *functional outcomes* that is being considered in this paper and is here reproduced by permission.

> Educational aims are frequently stated in terms of informational outcomes. This involves the doubtful assumption that these factual learnings will function in fulfilling the needs of the individual and of society. Courses of study often fail to point out the desired outcomes toward which the learnings contribute. Actually the situation is much worse than this, as the learnings are commonly obtained by logical analyses of topics, or so-called units, without regard to the needs either of the child or of society. The result of this procedure, which has prevailed both in elementary and high schools, is an unevaluated, though possibly logical, set of facts to be learned.
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> It would seem much better to start with the needs of the developing child and of the society of which he is a part. This requires a study of the personal needs and the social obligations of children. When we have analyzed the avenues of interest and satisfaction to be opened to young children, the matters of personal utility in which they need to become efficient, the specific scientific attitudes and procedures which they need to develop, the breadth of outlook possible to them, and the social attitudes and acts within their sphere of existence, we shall have the bases for planning our work in elementary science.
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> The specific aims in the following list are stated as desired functional outcomes. The teacher has not accomplished her purpose when, for example, the child knows something about sanitation, but only when he utilizes important sanitary measures. There is a vast difference between a knowledge of the principles of first aid and readiness to perform first aid. The facts are important contributing learnings, but the desired outcomes go beyond the factual learnings.[2]

It is the purpose of this discussion to suggest means by which we may hope to achieve some of these outcomes. It seems futile to expect functional outcomes to be achieved in any large meas-

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[1] *Functional Outcomes of Science Teaching in the Elementary School*, prepared by the following elementary teachers with the co-operation of W. C. Croxton, State Teachers College, St. Cloud, Minnesota: Primary—Violet Nelson, *Chairman*, Marjorie Broderick, Edna Carlson, Alice Cary, Donata Fleming, Betty Goehrs, Evelyn Heiner, Margaret Jamieson, Vernice Johnson, Cleo Russell, Ruth Saunders, Inez Starbuck, Leone Voltin, Dorothy Wray. Intermediate—Catherine McLean, *Chairman*, Florence Avery, Flora Cochrane, Evelyn Engen, Rose Hafner, Phyllis Johnson, Vera Lacher, Anna Manthey, Ruth Oleson, Jane Trevarrow, Janet Walker.

[2] *Ibid.*

ure unless we provide direct experiences designed to realize them. There is a vast difference between mastering text material that has potential usefulness and, participating in experiences obviously designed to meet clearly visioned needs. The abandonment of extravagant hope of transfer of training for the practice of directly seeking desired outcomes is probably the greatest need and the most important movement in education today. The textbook following, the logical units, and other traditional formalisms must be replaced by purposeful undertakings involving experiences and content obviously suited to foster the development of the desired attitudes, abilities, and tendencies.

The desired outcomes are arranged under major aims. The order in which these are listed is not intended to indicate relative importance. In each of the major lines of need, by way of illustration, activities are suggested that offer some hope of accomplishing one of these desired outcomes. A much more extended list of purposeful activities, arranged according to the outcomes sought, has been compiled by a group of elementary teachers in cooperation with the writer and will be published later.

I. Major aim—To develop in the children the tendency and ability to independently find satisfaction and recreation in the following ways:

Gardening
Attracting and observing birds
Following the activities of wild life
Rearing animals
Collecting
Constructing, experimenting, and playing creatively with toys and equipment
Enjoying and interpreting sky and weather
Keeping up with seasonal changes in the environment
Exploring
Enjoying out-door living: cooking, camping, hiking, and travel
Reading

If the child is to be led to independently find satisfaction and recreation in these ways, it is necessary that the school provide experiences that will interest and launch him in these pursuits. For example, if we desire that the child shall come to spend a part of his leisure time constructing, experimenting, and playing creatively with toys and equipment, we should make it possible at school for him to carry on activities such as the following:

Building and furnishing a playhouse
Building and sailing toy boats
Making toy water, wind, and steam power wheels and putting them to work
Holding a kite flying contest
Holding a glider race
Holding an airplane race
Finding of what materials things are made
Collecting and comparing construction materials
Installing miniature electric playhouse and street lights
Installing a doorbell
Discovering all the things a magnet can do
Making a simple compass
Making an electromagnet
Making a toy magnetic loading crane
Making an electric motor work for us
Making instruments for a rhythm band
Showing how our toys work
Changing substances to other forms
Modeling objects in clay or soap
Holding an exhibit of the best pictures we have taken
Winning the rank of elementary amateur photographer (All exposures on a film good)
Devising new set ups with a Mechano Set

II. Major aim—To develop in the children certain habits and abilities for their protection and efficiency:

Good health habits and abilities
Safety
Ability to do useful things efficiently

Let us choose one of the desired outcomes under this major aim and consider some of the suitable school activities for its accomplishment. Since the development of good health habits and abilities has been placed first in many lists of educational aims, we may well select this need. Many challenging experiences and much practice are needed to develop health habits. Activities such as the following offer much greater hope of functional realization than do traditional school lessons and textbook recitations.

Checking our physical efficiency on a self-rating scale
Deciding which health habits are important and checking ourselves regularly in these respects
Inspecting a hospital
Keeping up our permanent health record charts with the nurse or teacher
Holding a health care race
Holding regular inspection and cleanup and keeping a group-cleanliness progress chart
Getting ready during the last few minutes of intermission for work (getting a drink, visiting the toilet, washing)
Planning our day (work, play out-of-doors, rest, and sleep)

Finding which water supplies in the community have been tested and found safe
Pasteurizing milk
Discovering how flies eat sugar
Planning a meal
Shopping for simple foods that are not over processed
Playing restaurant (ordering meals free from concentrated sweets, highly spiced, highly processed, devitaminized, and demineralized foods)
Planning and packing a good lunch
Preparing a display of desirable and undesirable foods
Running a dairy at school for a day
Demonstrating how we dress in accord with weather and activity
Holding a posture improvement contest
Collecting pictures for a bulletin board display of good posture
Inviting a physician for a round table discussion on drugs and home remedies
Taking over the regulation of the temperature, light, and humidity of the schoolroom
Assembling a simple first aid kit
Demonstrating first aid methods for one's own use

III. Major aim—To develop in the children social attitudes, appreciations, and habits of service to society:

Active attitudes and participation in conserving human life, soils, wild life, clean waters, and natural habitats
Desirable natural attitudes in matters of sex and reproduction
Readiness to cooperate in keeping down weed and animal pests
Considerate and appreciative attitudes toward other people and other forms of life
Appreciation of our interdependence and of the contributions of others to our welfare
Appreciation of the value of useful property and a tendency to use it with consideration of the rights of others
A desire to emulate scientists who have contributed to humanity

The social aim has received more attention in recent educational literature and curriculum developments than any other need. It is of such critical importance, especially in a democracy where a large measure of freedom of individual action is permitted, that an active program for its realization is imperative. For want of space here to adequately consider such a program, let us select one great need, that of developing active attitudes and participation in conserving human life, soils, wild life, clean waters, and natural habitats. The following activities have been selected from a larger list of experiences which have been used by teachers to develop functional attitudes in conservation.

Organizing a traffic safety patrol
Organizing a sanitary squad
Demonstrating how we care for the sick
Playing quarantine
Experimenting with sterilized potato slices to find whether sneezing and coughing can spread bacteria

Organizing for mutual help in remembering to practice sanitary measures that will keep down the spread of disease
Making a study of the observance of traffic rules by pedestrians, bicyclists and automobile drivers
Cooperating with other boys and girls in a bicycle court
Presenting a play on safety first
Checking the playground and equipment to remove hazards
Playing "emergencies" and putting on a series of first aid demonstrations
Making a study of the work of the health officer in the community
Tracing the history of a stream valley
Making a study of a nearby gully
Comparing the "run off" from bare and vegetated places on the schoolground and surrounding areas
Making soil profiles to discover how much top soil is left in the community
Controlling erosion on the schoolground or some other lot
Discovering whether methods of checking soil erosion are being practiced in the community
Making a survey of spring wild flowers in the community
Protecting a wild flower nook
Putting on a campaign to teach people in the community to recognize the protected wild flowers
Decorating a living Christmas tree
Studying a nearby woods to find whether it is reforesting satisfactorily
Running a small school nursery
Reforesting a small unused patch of rough ground
Making a realistic living vegetation map of the state
Maintaining a bulletin board of "Vanishing Wild Life"
Finding the most interesting spots where the native life of the region still remains
Holding a scientific hearing of the evidence for and against the crows, hawks, owls, English sparrows, and other birds that are being killed
Inspecting a well managed swimming pool to learn what measures are taken to keep the water pure
Collecting samples of the water from swimming holes and bathing beaches to be tested at the water works (Secure sterilized and protected containers from the waterworks)
Discovering and considering possibilities of removing the causes of pollution of some swimming holes
Preparing a display on stream pollution

IV. Major aim—To contribute meaning to the elementary child leading to broader concepts:

Of the limitations of knowledge and the importance of discovery
Of the scientific method as a careful, orderly procedure for discovering truth and as man's most important tool
Of our changing conception of truth
Of the prevalence of natural law
Of energy as basic in all occurrences and materials
Of the vastness of space
Of the seemingly limitless extent of time
Of the determining influence of cosmic bodies, especially of the sun, on the earth and its regularly recurring happenings

Of natural forces bringing about continual change in the conditions for existence
Of a very old and changing stream of life in which only those forms survived that changed in ways suited to the conditions for existence
Of the highly organized state and self-regulatory nature of living matter
Of continued existence as made possible through recurring cycles of synthesis and decomposition
Of the environmental complex and its influence on living things
Of the possibility of directing the stream of life
Of the development of mind and of social responsibility
Of man as a part of nature, dependent but capable of intelligent participation, and very much needing to conserve the forms of life and the materials upon which his existence depends

The broad concepts of science are the outlooks which man has gained through the application of the scientific method in a multitude of specific situations. They represent the greatest perspective that the human mind has attained. They possess great guidance value to the individual once they are comprehended. It is not strange, however, that their comprehension is a matter of gradual growth. Just as they have been visioned as a result of a large number of significant experiences of mankind, so does the individual come to comprehend them only as a result of many suitable challenging experiences out of which grow significant meanings for him. It is doubtful whether a high degree of comprehension of any of the concepts listed as desired outcomes under this major aim can be attained through elementary science. There are meanings on an elementary level which should contribute to ultimate comprehension of all of them. It is essential to provide a rich experience basis for visualizing any abstract generalization. We need to formulate a great many suitable activities for each concept that contribute mean ing to the elementary child leading to ultimate comprehension. Again, let us choose one desired outcome, comprehension of the concept of the determining influence of cosmic bodies, especially of the sun, on the earth and its regularly recurring happenings. The following are some of the activities that afford opportunities to develop meanings on the elementary level that contribute toward comprehension of the concept.

Observing the happenings at sunrise, at noon, and after sunset
Keeping a nature calendar
Keeping a weather calendar
Operating a simple weather station
Comparing sun and shade temperatures
Discovering where ice and snow linger longest
Learning to guess time by the sun
Making a series of evening sky maps
Making an Indian moon calendar

Demonstrating night and day and the changing seasons
Carrying on a correspondence with someone in South America
Demonstrating eclipses
Making maple sugar
Making whistles
Setting up a bird-homecomer's gallery
Discovering what animals do as winter approaches
Discovering what people are doing to prepare for winter
Examining the plants as winter approaches
Making a collection of stones that tell a story of the past

V. Major aim—To develop scientific attitudes and habits of procedure:

There is no doubt as to the importance of this aim, although little has been done to achieve it. The desired attitudes have been well stated by Curtis and other workers. Scientific attitudes seem to be specific to a considerable degree. One may exhibit them in certain situations, but not in others. This raises the question as to whether we need to devise pupil undertakings specifically for the purpose of cultivating scientific attitudes or whether, on the other hand, all science activities should be carried out in such a way as to foster their development. The wide range of activities necessary to furnish a rich experience basis for achieving the other major aims would seem to offer the best opportunity for cultivating scientific attitudes and procedures that may be expected to function in varied life situations. Activities are capable of contributing to more than one outcome. The method is highly important.

A SIMPLE METHOD OF REMOVING "FROZEN" GLASS STOPPERS

Saylor C. Cubbage
Woodrow Wilson High School, Washington, D. C.

I have found it possible in the majority of cases to remove glass stoppers that have stuck merely by submerging the bottle in water in a convenient vessel. Rather than wrestle with the stopper I put the bottle in a jar of water while I go about some other task. After a class period or often less time than this has elapsed the stopper usually can be removed easily. The more difficult ones may require several hours' standing. The method does not work in all cases but in the many cases that it does work I find my little effort well repaid. It works very well with sodium hydroxide stoppers that have become lodged. Such a gentle method of treatment precludes any danger of breaking the stopper or the bottle. If this simple method fails to remove the stopper after several hours soaking then one can resort to the mechanical methods of removal. I have used this method with success in removing the glass stopper in burettes that have become "frozen."

APPROXIMATE SQUARE AND CUBE ROOTS

J. P. Harper
Professor of Mathematics
University of Scranton, Scranton, Pennsylvania

In solving problems in arithmetic and algebra it is desirable to have a quick accurate method of determining square and cube roots that will be correct to four or five digits. The mathematical method of finding square and cube roots often takes considerable time. The method herein presented does not take much time yet it is usually correct to four places. As a matter of fact if the numbers are simple three or four digit numbers almost any one can obtain the approximate square roots mentally. The cube roots are more difficult—involving more numerical calculation.

The method would seem to be highly commendable for use in connection with high school algebra where a knowledge of logarithms may be lacking. It is easy to learn and is easier to remember than the mathematical method.

The method is briefly this: to find the square root of a number N first get the nearest perfect two digit square root m, then add the difference $N-m^2$ divided by $2m$. This sum is the approximate square root. Thus,

$$\sqrt{N}=m+D/2m$$
$$\text{where } D=N-m^2.$$

Of course, this value of D can be either positive or negative depending upon the nearest perfect square. If it is below, the number, $N-m^2$ is negative, and if it is above, the $N-m^2$ is positive.

Proof of the method: the square root of any number can be considered as the square root of the nearest perfect square plus some quantity called x. That is,

$$\sqrt{N}=m+x,$$
$$\text{or } N=(m+x)^2=m^2+2mx+x^2.$$

From this last relation

$$x=(N-m^2-x^2)/2m.$$

Since x will usually be quite small, x^2 can be neglected so that one may consider

$$x=(N-m^2)/2m.$$

Of course one can estimate x^2 and substituting it in the equation get a very accurate result. Such a result might be termed the "corrected value."

Now consider some examples.

(a) Find the square root of 200.

$$\sqrt{200}=\sqrt{196}+(200-196)/2\times 14=14+4/28=14.1428.$$

Or, carrying out the more accurate calculation (x^2 being estimated at .02),

$$\begin{aligned}\sqrt{\ 00}&=\sqrt{196}+(200-196-.02)/2\times 14\\&=14+3.98/28=14.1421.\end{aligned}$$

The actual square root is 14.1421+. The first result is in error by .005%, the last one is correct to six digits.

(b) Find the square root of 14.2.

$$\begin{aligned}\sqrt{14.2}&=\sqrt{14.44}+(14.2-14.44)/2\times 3.8\\&=3.8-.24/7.6=3.8-.03158=3.76842.\end{aligned}$$

The "corrected value" is

$$\sqrt{14.2}=3.8-(.24+.001)/7.6=3.8-.03171=3.76829.$$

The actual square root is 3.76829. The per cent of error in the first case is .003%. The corrected result is correct to six digits.

The square root of a large number such as 629,324 can be found by considering it to be 62.9324×10^4. Its square root will be $100\sqrt{62.9324}$. Similarly a decimal fraction such as .000467 can be considered to be 4.67×10^{-4} and its square root will be $\sqrt{4.67}\times 10^{-2}$. In any event the actual number for which the square root is found will be between *1* and *1,000* for which it is relatively simple to find or guess the nearest two digit square root.

It is estimated that the greatest per cent of error would be 0.1% when no correction for x^2 is made. Even this amount of error in most cases is not so objectionable.

It has been shown in the examples above that the per cents of error in the square roots found by this method are quite small. A similar approximate method is applicable to cube roots. However, more work is necessary and the results are not quite so accurate.

To find the cube root of a number N get the nearest perfect two digit cube root m and add to it $(N-m^3)/3m^2$. That is,

$$\sqrt[3]{N}=m+(N-m^3)/3m^2.$$

The proof of the method is as follows: the $\sqrt[3]{N}$ can be considered to be the sum of the nearest perfect cube root m and a quantity x. Thus

$$\sqrt[3]{N}=m+x,$$
$$\text{or } N=(m+x)^3=m^3+3m^2x+3mx^2+x^3,$$
$$\text{from which } x=(N-m^3-3mx^2-x^3)/3m^2.$$

If the last two quantities are neglected in this equation then

$$x=(N-m^3)/3m^2.$$

After finding an approximate value for x a correction can be made in the original x equation and a very accurate value will be found. The x^3 part can be neglected without much error. Then

$$x=(N-m^3-3mx^2)/3m^2.$$

Now consider some examples.

(a) Find the $\sqrt[3]{2}$.

$$\sqrt[3]{2}=\sqrt[3]{2.197}+(2-2.197)/3\times1.3^2=1.3-.197/5.07$$
$$=1.3-.03885=1.26115.$$

The "corrected value" is,

$$\sqrt[3]{2}=1.3-(.197+3\times1.3\times.0388^2)/5.07=1.3-.20287/5.07$$
$$=1.3-.04001=1.25999.$$

The actual cube root is 1.25992 correct to six places. The first result is in error by 0.1% and the second is in error by .005%. This last value should be acceptable for almost any work.

(b) Find the $\sqrt[3]{152}$.

$$\sqrt[3]{152}=\sqrt[3]{148.877}+(152-148.877)/3\times5.3^2$$
$$=5.3+3.123/84.27=5.33706.$$

The "corrected value" is

$$\sqrt[3]{152}=5.3+(3.123-3\times5.3\times.037^2)/84.27$$
$$=5.3+3.101/84.27=5.33679.$$

The actual cube root is 5.33680, correct to five digits. The

first value is in error by .005% and the last value is in error by .0002%.

This method of finding a cube root, which gives highly satisfactory results, is certainly much less tedious and less difficult than the mathematical method. It can be extended to large numbers and to small decimal fractions by the same method suggested in the case of square roots.

Without the use of logarithms this method of finding square roots and cube roots should prove to be a great time saver and it gives results which can be made just as accurate as one desires.

ESTABLISHING THE MOST PERFECT BOUNDARY LINE

HARVEY W. MUNTZ, *Greenfield, Ill.*

Until recent years disputes often arose between the different bordering states about their boundary lines. The longest drawn-out dispute was probably between the states of Vermont and New Hampshire. The issue had been in dispute amost 150 years, and was finally settled some three years ago when the court approved the job of drawing the line along about 200 miles of the Connecticut River.

In settling these disputes many people along the disputed borders found that their citizenship and property was transferred to another state. The result was that voting addresses of many citizens were changed, disposition of taxes was altered, and pieces of property belonging to one state passed into the hands of the other.

When the Texas-Oklahoma boundary line dispute was settled in 1929 the border line became the most accurate one in the world, according to former Supreme Court Commissioner Samuel S. Gannett, whose job was to settle boundary line disputes between the states. This claim is based on the fact that it is on the line of the 100th degree meridian west of Greenwich.

Surveys for the Texas-Oklahoma boundary on or near this line were made in 1859–60, 1873, 1875, and in 1902–03, but none of these was accepted as fixing the boundary, as neither Congress nor the State of Texas approved any of them; consequently none had any legal status.

In October, 1926, the United States Supreme Court decreed (272 U. S., 21) that neither the boundary survey of 1859–60, nor the location of the 100th meridian in 1902–03 could be accepted as establishing the boundary, and ordered that a new survey be made. This court decision gives a detailed history of the various surveys for the establishment of the 100th meridian.

The mark set in 1929 for the northeast corner of Texas is in latitude 36°, 29′, 59.56″; longitude100°, 00′, 00.00″ west of Greenwich, and is 286.5 feet southeast of the mark of 1903. The geodetic line as now marked is 4,040 feet east of the south end of the 1859–60 line, and about 880 feet east of the north end of the line as marked in 1859–60 and retraced in 1873. The strip of land included between these two lines has an area of about 44.6 square miles, and is thus determined to be in Texas, and not in Oklahoma.

THE TWELVE-YEAR SCIENCE SEQUENCE

PHILIP B. SHARPE
Greenwich, New York

Scientific belief, attitude, method, and skill play such an important part in the modern world that they should play an equally important part in modern education. For this reason, many schools and some states are putting in a complete 12-year program of science teaching. And rather than have the grade science taught by a special teacher who might run from room to room with a truckload of materials, but who could not hope to know all his pupils intimately, or to associate their science work very intimately with their personal problems and other subjects, these schools generally have the grade science taught by each teacher in her own grade.

A great teacher can make almost any subject interesting, valuable, and inspiring; a poor teacher can make any subject dull, worthless and depressing. For this reason, all problems of curriculum and administration are to a great extent problems of teacher selection, teacher training, and teacher freedom. But while this is very true of such standardized, routinized, and delimited subjects as physics and chemistry, it is more true of elementary science wherein the teacher has a new field, and the freedom and opportunity to make a very great thing, or a very little thing of it.

The success of these programs depends then, upon what the grade teacher does with her opportunity. And the usual grade teacher is very poorly adapted to science teaching. She has taken very little science, sometimes none. What little science she may have had was cut and dried material designed for older pupils than her own. It consisted almost entirely of rote learning. She is helpless and bewildered by this latest addition to her many activities. She will probably get a set of science readers, and her science teaching will consist of making her pupils read about science for so many hours or fractions thereof per week.

It probably does the pupils no more harm to read about science for so many minutes a week than to read about famous American authors, or the rivers of Bolivia, or how Japanese children tend their gardens, for an equal period of time each week. But it should be distinctly understood that such reading is not science teaching. Science is doing things and discovering things from nature. And doing and discovering such things for

one's self. It is a method of solving problems for one's self by observation, reflective thinking, and experiment. It is a field, workshop, and laboratory activity, not a library and easy-chair resort. It is most unfortunate that the usual elementary teacher does not know how to begin a real science program.

To help the grade teacher in her dilemma, it is usual to appoint a Senior High School science teacher or head to be Elementary Science Supervisor. He may be given that title or that of Science Specialist, which sounds good; and sometimes he is relieved of a small part of his former duties so that he will have some time, energy, and enthusiasm to spare for his new and big task. Under his supervision, the grade teacher may be provided with a little scientific apparatus, answers to her questions of scientific fact, and an enormous bibliography which is respectfully filed away among her many papers. Also, she may be taught how to supplement her cut and dried reading assignments with an occasional cut and dried demonstration, performed without skill or comprehension.

The sad truth of the matter is liable to be that the supervisor has very little help for her. His own college entrance teaching has been the ramming home of scientific facts in preparation for factual college entrance examinations. He has taken more science courses than she, but these also consisted of rote learning and routine laboratory performances. He has never come within gunshot of the scientific method; he is no scientist; he doesn't know what it is all about.

"How is this?", one will wonder. "Hasn't he had college training in science; don't the colleges and universities train men for original work?"

The answer is, "Yes. But, believe it or not, it is for precisely that reason, and the way the colleges go about it, that he has a training which is in a way worse than none at all."

The college and university train men for research. In science, research means the solving of original problems by means of the scientific method. By "original problems," the college and university mean problems not yet solved by the human race. And so to save time, they first give him a thorough grounding in the facts discovered to date. He memorizes mountains of material and acquires background for his original work of the future. In other words, he follows the beaten track to the frontiers of knowledge. Training in scientific method is reserved until the very end, say two years before receiving his doctor's degree. And

men who have received the *complete* scientific training and their doctor's degrees very seldom seek high school jobs.

But even if we could get competent men with that complete scientific training for our schools, we do not want men trained to avoid duplicating the discoveries of the past so as to do research entirely original to the whole of mankind. We want men trained to understand children and help them solve their own problems by means of the scientific method. We want men to whom every personal problem is fresh and new and *original to the person solving it.*

Such a man will hide his factual knowledge in his teaching and help people to help themselves. His answer to the perennial question of children, "Can I make milk by mixing cream and water?", is not, "No. There are many mineral salts, casein, etc. in the skimmed milk which would be missing from the mixture." His answer would be, "I don't know. How could we find out?" And when they had tried the mixture and *found out for themselves by means of the scientific method* that the answer was No, he would ask them, "Well now, I wonder why. How can we test William's idea?"

He will not be particularly interested that the students get filled up with scientific facts, although they cannot help getting a good many. But facts can be discovered as needed, but can seldom be wisely applied without scientific method. He will recognize the wide gap between theory and practice and emphasize method, the indispensable factor.

He will realize that it is exceedingly silly to teach all his pupils as though they were going to become Ph.D.'s in Chemistry or some other science. Consequently he will not give them part of the ground work for professional training, which is now the curse of physics and chemistry in the high school. He will teach the things of most worth to citizens in general. And whatever fads and fancies may come and go, the school which trains its students in the basic skills of learning is not doing a bad job of education. If a citizen can read and write and figure, and also solve problems for himself by means of reflective thinking and scientific method, he has a pretty good start in life. He can learn whatever more he is liable to need. He is more worthy of his hire than a mere walking encyclopedia of miscellaneous facts.

In short very few grade teachers (and very few science heads) have received suitable training for worthwhile science teaching. To extend the science program at this time is often to extend

rote learning rather than to extend what may be properly called "science teaching."

For these reasons, the adopting of a 12 year science program would seem of very doubtful advantage unless suitable science training is provided for the grade teachers. The two problems should be considered together. The grade teachers will require a laboratory course in solving common student problems by means of scientific method. This will give them a working conception of the scientific method, and confidence in their ability to guide students aright in the students' problem-solving activities. In addition it should give them the thrill and spirit of scientific discovery. The teacher of this course will treat them to the same zestful activities to which they in turn will treat their pupils.

It must be admitted that such teachers and such courses are very rare, almost non-existent. However, that is the necessity and the problem which must be solved if science teaching is going to be worthwhile and contribute what it ought to general education. Some progress has been made and is being made along this line, and helpful suggestions can be found in the more important books and periodicals on science teaching.

DEMONSTRATING THE TIP OF THE EARTH AS A CAUSE OF SEASONAL CHANGE

William A. Porter
Chisholm, Minnesota

Apparatus; A globe or suitable substitute and a flashlight.

Method: Using chalk sketch a circle about 15 feet in diameter on the floor of the room. This circle represents the orbit of the earth. Set the globe so that its axis is tipped 23.5° from the perpendicular and place the globe on the orbit in the winter position as shown in Fig. 1. Hold a flashlight parallel with the floor and on the level of an imaginary line passing through the center of the globe. When the globe is rotated the children can see that the territory within the Arctic Circle receives very little light while much of the Antarctic area experiences continual daylight. It is also easily seen that at mid-day the sun is directly overhead at Rio de Janeiro and at the same time in

the northern part of the United States the sun occupies a rather low position in the sky. The climatic effects of this phenomenon should be discussed at this time, including a consideration of your own locality.

Move the globe to the position on the orbit designated as spring and note that at mid-day the sun is directly overhead at the equator. Rotate the globe and point out that equivalent points in each hemisphere receive equal amounts of light. Move the globe to the summer position and rotate it. The Arctic Circle now sees the midnight sun and the Antarctic experiences a 24-

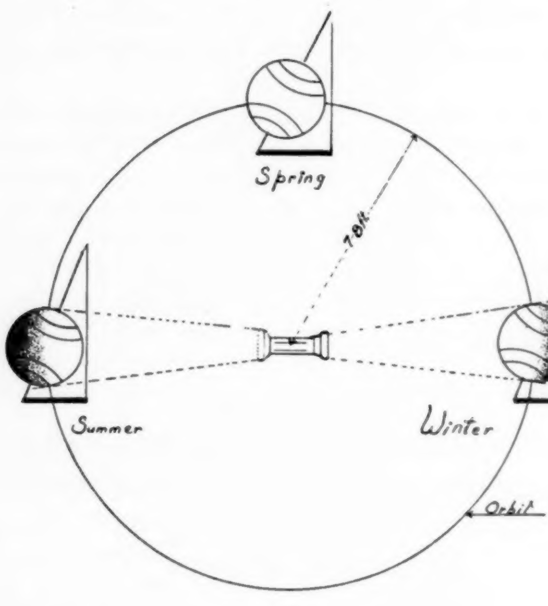

FIG. 1

hour night. This demonstration should be accompanied by charts and diagrams similar to Fig. 1. The students may then be asked to place the globe in the position where autumn begins and explain the shortening of the days and the lowering of the temperature. It should also be brought out that summer and winter are relative terms whose meaning is determined by our location on the earth.

(Obviously it will be necessary to draw the shades in performing the above exercise and it might be wise to pick a cloudy day as well.)

THE INDIRECT METHOD IN GEOMETRY

Charles H. Butler
Western State Teachers College, Kalamazoo, Michigan

A short time ago while I was reviewing a checking list of desirable and undesirable characteristics of geometry teaching[1] my attention was caught by one particular item in the list. This item had reference to the matter of indirect proof in geometry. The author of the list took the position that this method of proof should be employed only in cases where its use is unavoidable, holding that the amount of time devoted to indirect proof should be reduced as far as possible and, by implication, that any avoidable use of the indirect method is to be deplored.

I have long been aware that there is a widespread disposition on the part of many teachers and students alike to regard indirect proof as a difficult and undesirable feature of geometric study,—as a sort of necessary evil, to be utilized only when and only to such extent as may be absolutely necessary (and then apologetically) and to be avoided on all possible occasions. But the endorsement, by publication in a highly reputable professional journal, of the recommendation that " . . . a *minimum* (italics mine) amount of time (be) devoted to indirect proof . . . "[2] gives to this position a note of authority and a sanction which I feel to be totally unwarranted and which I feel should be publicly called in question. Therefore I wish to take issue with this recommendation and to present some considerations in defense of the indirect method. Lest my position be misunderstood, it should be made clear at the outset that in defending this method of proof and of reasoning I have no thought of advocating its exclusive use. What I shall have to say will contain no indictment, either direct or implicit, of the direct method of proof. I merely wish to point out some considerations which I feel are important, and which I am sure have escaped the attention of most of the teachers of geometry.

One evening last winter I turned the switch of a floor lamp near my desk, but the lamp failed to light, and thereby a problem was set for me. Several possible explanations suggested themselves. No other lights were burning in the house at the time. Perhaps a fuse had blown or for some other reason the

[1] Franzén, Carl G. F., "Improvement Sheet for Plane Geometry," School Science and Mathematics, XXXIII, March 1933, pp. 293–296.

[2] *Ibid.*, p. 293.

current was temporarily off. Or perhaps the floor plug or the wiring leading to it had become defective. Or perhaps the bulb had burned out. Or perhaps there was a defect in the wiring of the lamp itself. I do not know that at the time I consciously formulated these possibilities into an exclusive list. They occurred to me almost simultaneously, and I know I did not write them down. But I did set about testing them one by one. First, I snapped the wall switch and the top lights went on at once. Obviously, then, the house current was not off, and I had limited the field of investigation somewhat. Next I removed the bulb and inserted it in another lamp socket where it burned as usual. The bulb, then, was not defective and the field of investigation was still further limited. To test the floor plug I plugged in my radio which was nearby and got a normal reaction. This eliminated a third possible source of the trouble, and I reasoned that the defect must therefore be in the wiring of the lampstand itself. To check this I plugged the lamp into another floor plug. It still did not light and I set it aside for the evening. The next day when I removed its wiring I found a broken wire just inside the base of the lampstand. I rewired it and have had no trouble with it since.

The situation which I have described is, of course, trivial (though real), but it illustrates well a type of reasoning which I feel is not at all trivial, and it is a fair sample of the way in which such reasoning is often used in practical situations. I refer, of course, to what we generally call indirect reasoning. This may be described as the method of reaching a conclusion indirectly through the investigation and elimination of all possibilities except one. The method of trial and error is a well-nigh universal method of investigation. Random trial and error sometimes produces results of value but it cannot be depended upon to do so because it is not accompanied by any assurance that all possibilities in the given situation will be investigated. But the method of trial and error *in the presence of a plan* is the accepted scientific method of investigation, and it is essentially this which we mean when we speak about indirect reasoning. Such a method is more likely than random trial and error to reach valid conclusions because the presence of a plan implies that all possibilities will be investigated.

Indirect reasoning, then, is essentially the method of planned trial and error. It is a type of reasoning which is practiced, probably, by all individuals who are capable of doing any reasoning

at all, and it makes up a large part of the thinking of most people. The number and variety of situations to which it is applicable is almost unlimited. Indeed the noted logician Jevons has estimated that about half of all our reasoned conclusions are arrived at through this method of indirect reasoning.

We are specially interested here in considering the application of this type of reasoning to mathematical situations, and particularly to elementary geometry. The National Committee on Mathematical Requirements in its report[3] published in 1923, stated as one of the principal objectives of instruction in demonstrative geometry " . . . to develop understanding and appreciation of a deductive proof, and the ability to use this method where it is applicable." There is abundant evidence that this emphasis on the essential meaning and nature of deductive proof has not diminished in the fifteen years which have elapsed since this report was published. On the contrary, it has increased to the point where one does not hesitate to assert that it has now become the principal stated objective for instruction in demonstrative plane geometry. A striking illustration of this is found in the account of the experimental work which has been and is being carried on in the geometry classes of the laboratory schools at Ohio State University by Dr. Harold P. Fawcett. This has recently been published as the *Thirteenth Yearbook of the National Council of Teachers of Mathematics* under the title of *The Nature of Proof.* It is to be noted that the title of this book, which is the same as the title of the course which Dr. Fawcett gives, does not contain the word "Geometry" at all, though the students receive credit for plane geometry, which makes up much of the formal subject matter of the course.[4]

Now let us apply the principles of deductive reasoning to the situation which we are considering here. We find that one of the main objectives, if not the main one, of demonstrative plane geometry is to develop an understanding and appreciation of the nature of deductive reasoning. Indirect reasoning (or indirect proof) is a form of deductive reasoning which is extensively used by nearly everybody. Then it would seem to follow necessarily that the course in demonstrative plane geometry should include a good deal of work emphasizing the nature and method and the broad applicability of this type of reasoning.

[3] National Committee on Mathematical Requirements, *The Reorganization of Mathematics in Secondary Education*, Mathematical Association of America, Inc., 1923, p. 34.

[4] A most interesting commentary on this course which Dr. Fawcett has been offering is found in *Time*, Vol. 33, No. 3, July 18, 1938, p. 46.

In line with this contention I shall quote a statement by the present President of the National Council of Teachers of Mathematics. This statement is as follows:

"If geometry is to be taught largely because of its inherent possibilities to provide experiences in the science of reasoning, . . . then surely it is a mistake to omit or neglect to emphasize the method of the indirect proof. Much of the reasoning which we do in life is indirect; therefore much of the value of geometry must be in its treatment of indirect proof."[5]

Theory and practice, however, are quite at variance with respect to this question. The textbooks in plane geometry contain surprisingly few cases employing or requiring indirect proof. In comparison with the number of cases involving direct proof this number is negligible.

It has already been pointed out that indirect reasoning is used in many life situations, and that it is generally used in a more or less intuitive or non-formal way. When applied in this way to ordinary situations indirect reasoning is not usually hard to understand nor to employ. It seems a "natural" way to arrive at conclusions. But in geometric situations the case seems, for some reason or other, to be reversed. The *direct* proof here seems to be the natural line of reasoning, and indirect proof appears to be something foreign, artificial and unsatisfactory. Perhaps this is largely because so little opportunity is afforded for the practice of indirect reasoning in geometry. With respect to this, a noted authority makes the following comment:

"To instruct the pupil thoroughly in indirect proof will require about five to ten times as much time and effort as is ordinarily given to this type of proof in high school classes today."[6]

For various reasons, however, I am afraid that we may not reasonably expect anything like a balance between opportunities for direct proof and indirect proof in the geometry course. I believe we shall have to look to another source for any material correction of the present unfavorable attitude toward indirect proof. This source I believe to be an improved understanding of the fundamental nature of indirect proof itself, and the development of a technique of indirect proof which shall be general but at the same time well defined. I believe that the fundamental *technique* of indirect proof is so intimately related to the funda-

[5] Christofferson, H. C., *Geometry Professionalized for Teachers* (Privately published), Oxford, Ohio, 1933, p. 138.

[6] Upton, C. B., "The Use of Indirect Proof in Geometry and in Life," *Fifth Yearbook of the National Council of Teachers of Mathematics*, New York, 1930, p. 124.

mental ***nature*** of indirect proof that to explain the nature of the process is to imply the technique or the machinery. Let us, therefore, examine with care the fundamental nature of indirect reasoning and indirect proof.

For purposes of illustration we may refer to the case of the defective floor lamp which has already been described. It was shown there by indirect reasoning that the defect was in the wiring of the lampstand by showing that the defect was ***not*** somewhere else in the circuit. The basic assumption leading to this conclusion was that either (1) the defect *was* in the lampstand, or else (2) that it *was not* in the lampstand. Note particularly these two propositions. They constitute what is called, in terms of formal logic, a pair of ***contradictory propositions***, and such a pair of propositions always has the following characteristics:

(a) they cannot both be true at the same time;
(b) they cannot both be false at the same time;
(c) if one of them is false, the other must be true;
(d) if one of them is true, the other must be false.

If we wish, then, to prove one of two contradictory propositions true, it is sufficient to prove that the other one is false. This, in summary, is the essence of indirect proof in its simplest and most elemental form. It is based upon two fundamental and complementary laws or postulates of logic which, in turn, rest upon a third principle of logic for their application. These two laws are known as "the law of contradiction" and "the law of the excluded middle." The law of contradiction asserts that a thing cannot both be and not be. The law of the excluded middle asserts that a thing must either be or not be. The above-mentioned characteristics of a pair of contradictory propositions are corollaries to these two postulates of logic and really give us our definition of contradictory propositions. This, of course, is to the effect that if there exist two propositions having these characteristics one of them must be true and the other one must be false.

The application of these two laws depends, as has been said, upon a third postulate of logic which asserts that there are only two ways in which a false conclusion may be reached. Either (1) the reasoning may be incorrect or (2) at least one of the assumptions upon which the reasoning is based may be false. If neither of these conditions exists in a given case, the conclusion

which is reached must be correct. If either or both exist, the conclusion may be false. If, then, one reaches a false or inconsistent or contradictory conclusion, and if he can be sure that he has reasoned correctly, it necessarily follows that he must have started out with at least one false assumption.

In the case of the defective lamp I performed a *series* of indirect proofs, each based upon the principle of contradictory propositions, the last such proof being the one through which the trouble was finally located. I took first the one which could be tested most easily. I suppose my thinking, if it had been recorded in formal fashion, would have comprised the following pair of contradictory propositions:

1. The house circuit is on;
2. The house circuit is not on.

The simple test of snapping the wall switch showed conclusively that the second of these was false and that the first one was true.

Next, a pair of contradictory statements about the bulb:

1. The bulb is defective;
2. The bulb is not defective.

By inserting the bulb in another light socket it was shown that statement 1 of this pair was false and that statement 2 was true. In other words, the bulb was not defective.

Similar reasoning and testing led to the conclusion that the floor plug and its wiring contained no defect. Since my list of possibilities included only four, the remaining one would have been set up something like this:

1. The trouble is in the lampstand;
2. The trouble is elsewhere.

Note that the "elsewhere" included the only three possible locations of the trouble other than that mentioned in 1; namely, in the lampstand itself. Each of these three had been checked by a physical test and it had been shown that the trouble was not traceable to any of these three sources. In other words, the trouble was not "elsewhere." The conclusion necessarily followed that since the second of these two contradictory propositions was not true, therefore the first one must be true, and the trouble must be located in the lampstand itself. I have stated that I checked this conclusion experimentally afterward, but I

need not have done so ***provided I had been certain that all the other possibilities had been included in the "elsewhere."*** By sheer application of the principle of indirect proof I would have been absolutely sure that the trouble had been located beyond the possibility of any question.

While this illustration is a typical example of the way in which indirect *reasoning* may be applied to practical life situations, there are, I think, at least two points of distinction to be noted between this mode of indirect *reasoning* and the application of indirect *proof*, in its most elemental form, to propositions in geometry.

In the first place (and perhaps in some ways this is unfortunate) propositions in geometry are generally so stated that one knows at the outset the particular thing which he is required to establish. "*Prove that* under such and such conditions *so and so will be true*." In the case of the lamp, as in many practical situations, it was not so simple as this at the outset. It was not a case of "prove that the trouble is in the lampstand," but rather, "find out in which of several possible places the trouble is located." In life situations the problems are generally not so strictly defined and delimited in the beginning as they are in most propositions in geometry. Moreover, it is generally easier in geometric situations than in life situations to be sure that all possibilities have been included in the set-up of the problem. This, to my mind, is a really fundamental distinction between indirect *proof* and indirect *reasoning*. Though the terms are generally used synonymously, I conceive indirect proof to be a formal and highly specialized form of indirect reasoning. In other words, I regard all indirect proof as indirect reasoning, but I do not accept the converse of this statement.

Secondly, the *procedure* is not identical in the two cases. It is usually more formal in geometry. We set up our pair of contradictory statements, select at once the one which we wish to prove true, and then set about showing that the other is false by supposing it to be true and then showing, through a chain of logical reasoning, that this supposition necessarily leads to a contradiction or an inconsistency. This is the recognized and well-defined procedure.

On the other hand, in practical situations we rarely set down our possibilities in the manner of formal contradictory statements. We generally proceed more or less intuitively. But even if we should formalize the problem, our investigation of possi-

bilities will often (and legitimately) be more in the nature of open-minded experiment than by way of establishing a preconceived opinion by logical reasoning. For example, when I tested the light bulb I really did so not with the idea of proving logically that it was defective nor with the idea of proving that it was good, but rather, with the idea of *seeing whether or not* it was defective. Such experiment often requires less mental effort than the formal proof of the falsity of a geometric proposition, so that while indirect proof in geometry is generally less complicated in its initial set-up, this advantage is probably more than offset in many cases by the difficulty of the intellectual effort required in the investigation. *I think this may explain why many people who have difficulty in using formal indirect proof in geometry are able quite successfully to apply more or less informal indirect reasoning in non-geometric situations.*

So much for the nature of indirect reasoning and indirect proof. Let us now turn our attention to the *technique* or the *machinery* of indirect proof in geometry, because I think that if indirect proof is ever to come to have an emphasis in the geometry course commensurate with its importance it will be largely through making teachers familiar with this machinery. I feel sure that at present most teachers are not familiar with it. Even in the textbooks the workings of the plan *as a general method* are not made sufficiently clear. Each proposition is treated as a sort of trick problem, and as a result neither teachers nor students gain much appreciation of a general technique for this work, and often both come to regard all indirect proof as a bag of tricks invented for their bedevilment.

As has been said, the technique of indirect proof can be reduced, at least in outline, to an almost machine-like operation. It consists of four steps, and they are always taken in the same order, which is as follows:

1. Set up a pair of contradictory propositions, one of which it is desired to prove true. Select this one at the outset.

2. Assume (for the time being) that the other one is true, and test the consequences of this assumption by deductive reasoning to see whether the assumption leads to a contradiction or to an inconsistency.

3. If the assumption does lead, by correct reasoning, to an inconsistency or a contradiction, conclude that it was a false hypothesis, in which case

4. Conclude that the other one of the contradictory proposi-

tions (that is, the one which it is desired to prove true) is necessarily true, since the only alternative proposition has been shown to be false.

This machinery of indirect proof is perfectly general, and its essential form is rather simple. My experience has been that it can be learned and understood without much difficulty by normally intelligent fifteen-year-old children. I have experimented with it in a limited way, and I have felt that a good many of the students find the almost mechanical operation of the process quite fascinating. Moreover, I have about come to the conclusion that it is no more difficult in principle than direct proof.

One feature which was troublesome for a while is the clumsy wordiness inseparable from the verbal statement of the denial of the hypothesis in step 3. This hypothesis is generally stated in negative form, and if the denial of a negatively stated proposition is verbalized, the statement tends often to become so complex that either its analysis or its significance would tax the powers of an expert grammarian, and most high school sophomores are not expert grammarians.

To overcome this difficulty we hit upon the plan of writing out separately the complete and careful statements of the two contradictory propositions in step 1 *and then substituting for each of these statements a single identifying symbol.* The Greek letters θ and ϕ were chosen merely because it was felt that they were not likely to be confused with the customary symbols used in identifying points, lines, etc. The choice turned out to be a happy one for another reason: namely, that the newness of these symbols aroused the curiosity and interest of the students, and as a by-product of this focusing of attention the mechanical outline of indirect proof tended to crystallize in the students' minds more quickly and more definitely than had been expected.

The use of these symbols enabled us to eliminate a great deal of the verbal confusion which I have mentioned and to shorten both written and oral exposition with, I think, a corresponding increase in understanding of the mechanics and the nature of indirect proof.

To illustrate, let us consider the proposition that "Two straight lines, both perpendicular to the same straight line, are parallel to each other." The demonstration, following the outline described but not employing the symbolic representation of

the contradictory statements would be set up in some such manner as this.

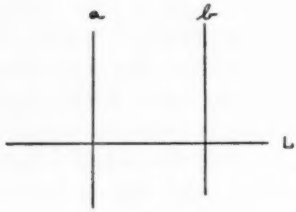

FIG. 1

Given: $a \perp L$ and $b \perp L$.
Prove: $a \parallel b$.
Proof:

(1) Either a is $\parallel$ b or a is not $\parallel b$	Contradictory statements
(2) Suppose a is not $\parallel$ b	Tentative assumption
If a is not $\parallel$ b then	
a must intersect b	Definition of $\parallel$ lines
in which case we would have two lines both $\perp$ to a given line from a single point; and we know this to be impossible	Theorem: Only one line can be passed $\perp$ to a given line from a given point.
(3) Therefore it is not true that a is not $\parallel$ b	Because the assumption that this is true leads to a contradiction of a previously proved proposition.
(4) Therefore a is $\parallel$ b	Because if one of two contradictory propositions is false, the other one must be true.

This is a perfectly correct and valid proof, but its statement is rather confusing in the third step where it is necessary to use the double negative or else to avoid the use of the word "parallel." Now if we should set up this proposition in the symbolic form which has been described we would have something like this: (we may use the same diagram and statement of hypothesis and conclusion)

(1) a is $\parallel$ b .... θ; a is not $\parallel$ b .... ϕ	Contradictory statements
(2) Suppose ϕ is true	Tentative assumption
(3) and by reasoning similar to that used before, show that ϕ leads to a contradiction of a previous theorem	Theorem: Only one line . . .
(3) Therefore ϕ is not true	Because it leads to a contradiction.
(4) Therefore θ is true	Because its contradictory is false.

Observe that the statement "ϕ is not true" is much more concise and less confusing than the verbal statement "it is not true

that a is not parallel to b." Moreover, experience has shown beyond doubt that the use of this symbolic representation of the two possibilities in setting up the theorem distinctly increases the students' perception of the essentially contradictory nature of the two statements and perceptibly clarifies for them the mechanics of the job.

There are, of course, cases in which the set-up of the problem contains more than two possibilities, but even these cases conform to the pattern which has been described if we admit the reapplication of the technique. Take, for example, the proposition: "If two angles of a triangle are equal, the sides opposite these two angles are also equal."

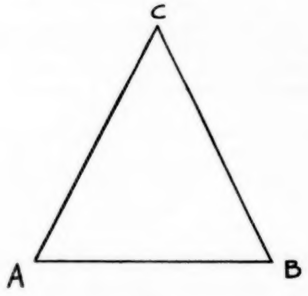

FIG. 2

Given: $\angle A = \angle B$
Prove: $BC = AC$
Proof:

$$(1)\quad \left.\begin{array}{l} BC=AC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \theta \\ \left.\begin{array}{l} BC>AC \ldots\ldots \phi_1 \\ BC<AC \ldots\ldots \phi_2 \end{array}\right\} \ldots\ldots\ldots\ldots \phi \end{array}\right\} \ldots\ldots\ldots \text{Contradictory statements}$$

(2) Assume ϕ_2 and show that this assumption implies a result that is contrary to the hypothesis. Next, assume ϕ_1 and show that this assumption also implies a result that is contrary to the hypothesis.

(3) Therefore ϕ is not true .... Since neither of all its possible forms is true.

(4) Therefore θ is true .... Since the only alternative proposition has been shown to be false.

It would be easy to give numerous additional illustrations of this symbolic treatment of three-possibility propositions but it is not necessary. The foregoing illustration makes it clear that this type of proposition is easily amenable to the symbolic treatment, and that by a reapplication of the contradictory

proposition principle it can, without difficulty, be made to fall into the basic pattern of our general technique. Even the further increase of the number of possibilities would not alter the situation, though it would increase the number of subscripted ϕ's. When students become really conscious of the fact that all such indirect proofs can be made to fit into this essential framework the method of indirect proof will be no longer a mysterious, dreaded, unrelated aggregation of tricks, but instead, a highly systematic, understandable and powerful method of work, supplementing the direct method, it is true, yet challenging and fascinating in its own right.[7]

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[7] Author's note: The present article is a slight modification of a paper presented before the Mathematics Section of the Michigan Schoolmasters Club at Ann Arbor, Mich., on April 29, 1938. The author wishes to acknowledge his indebtedness for many ideas on indirect proof to Professor C. B. Upton of Teachers College, Columbia University, and to Dr. H. C. Christofferson of Miami University, to whose publications on this subject reference has been made. In particular, the writings of Professors Upton and Christofferson treat in considerable detail the "Law of Converses" which has not been touched upon in the present article.

It is interesting to note that the machinery of indirect proof as described in the foregoing pages is equally applicable to the proof of numerous theorems of algebra, among which may be listed the basic theorem: "Any integral rational equation $F(x)=0$ of degree n has exactly n roots, a root of multiplicity m being counted as m roots."

SOME EASY PROJECTS IN CHEMISTRY. NO. VI. SUGAR FROM SAWDUST

Oliver Edwards, Jr., *Senior High School, Orlando, Fla.*

When the instructor suggested that I make sugar from sawdust, I said to myself; "Oh Yeah!" I didn't think it could be done. But it can.

I put a small handful of sawdust into a flask with 40 cc. of water and shook it well in order to wet the sawdust. Then I added 10 cc. of dilute sulphuric acid. After shaking, the liquid was heated in the flask over asbestos gauze on a ring of a stand. I kept it at a gentle boil for about half an hour, replacing water as it boiled away. Then I drained off some of the clear liquid and tested with Fehling's Solution No. 1 with enough of No. 2 to give a deep-blue liquid. On heating this in a test tube, a reddish product was obtained. This is a test for reducing sugars. The same result was obtained by treating a little of a solution of glucose; the same reddish color appeared. So I concluded there was sugar in the liquid obtained from sawdust as above.

It seems that cellulose (sawdust) $C_6H_{10}O_5$ takes up water H_2O and becomes sugar $C_6H_12O_6$.

$$C_6H_{10}O_5+(H_2SO_4)+H_2O \rightarrow C_6H_{12}O_6+(H_2SO_4).$$

The sulphuric acid is just a catalyst. I thought this experiment was O. K. till the question came up; "How are you going to get rid of the sulphuric acid?" The instructor suggested I try sodium hydroxide solution, NaOH. This neutralizes the acid and converts it into sodium sulphate, so that at the end you have sugar solution with a little sodium sulphate in it. The sulphate is harmless.

This process is carried on in Germany in a big way for the production of cattle feed.

LECTURE ROOM STOP WATCH

F. H. WADE
Lewis Institute, Chicago

A stop watch with a dial large enough to be read from all parts of the room, capable of splitting a second into ten parts, and with direct, remote, and automatic control, can be made easily at small cost.

The operating principle is the same as that of the ordinary electric clock. An electric motor with a reducing gear drives a pointer around a dial at constant speed. The pointer is arranged to be engaged or disengaged at will while the motor runs continuously.

The motor, a shaded pole, self-starting, 60 cycle, 110 volt

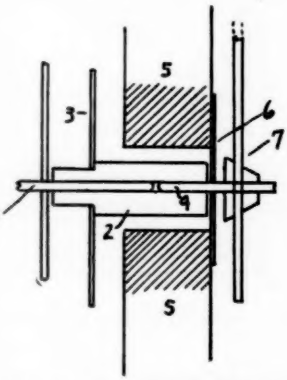

FIG. 1. The final shaft of the reduction gear.

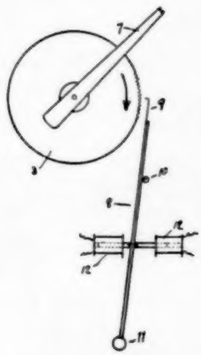

FIG. 2. The timing gear and mechanism.

machine, together with a 450 to 1 reducing gear mounted as a unit, can be purchased from the Speedway Manufacturing Company, Cicero, Ill., for the sum of $2.50. There remains to be made only the dial, pointer, and clutch. An old drawing board will serve as a dial, a piece of balanced balsa wood will do for a pointer, and the clutch may be made in a great variety of ways. I have tried many schemes, including the magnetic type, but as is usually the case, the simplest turns out to be the best.

Referring to Fig. 1, member 1 is the final shaft of the clockwork reduction gear which turns in my case at 8 revolutions per minute. This requires the peculiar scale of 7.5 seconds for once around the dial. Quite satisfactory for ordinary use since but

few demonstrations are longer than that length of time. Should an even scale such as 4 or 10 be required, there is no reason why the gear ratio cannot be changed. Referring again to the figure, the piece 2 is a sleeve of brass or wood fitting loosely on the shaft with just enough friction to overcome the slight inertia of the pointer. The sleeve is turned with a shoulder against which is fixed the clock wheel 3. A detent or pawl engages the teeth of this wheel, stopping the hand but not the motor. The wheel can be recovered from some old clock movement and should have a large number of teeth, say 75 or 100. The length of the sleeve

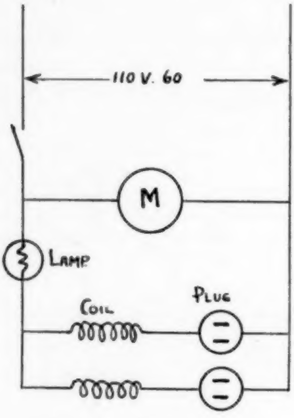

FIG. 3. The electric circuit.

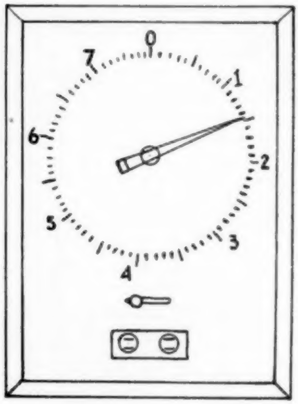

FIG. 4. The clock dial.

should be such that the large brass or tin washer 6 fastened to the front of the drawing board will serve to hold everything in line. Shaft 4 carrying the pointer 7 fits loosely in the sleeve so that the pointer can be reset without disturbing other parts of the mechanism. The arm 8, Fig. 2, made of a light piece of wood or other suitable material, should be a little longer than the pointer and is provided with a spring brass tip 9 bent at the end to fit teeth of wheel. The arm is attached to the back of the drawing board by the bearing or pivot 10 dividing the arm at say 5 to 1. The pivot should be slightly outside a tangent line so that the tip will not be likely to slip out of engagement. At the end of the arm is the finger knob 11 which extends to the front of clock through a slot in the board. Movement of the arm should be limited to the proper amount by means of suitable stops. When the clock is completely assembled, the exact time

for a revolution should be determined, and the dial laid out accordingly. While the motor is not synchronous, the speed is substantially constant.

Manual control will be found quite satisfactory for most demonstrations. The personal time-lag is very small, even negligible, for any event that can be foreseen or predicted. If remote or automatic control is desired it can be obtained by a pair of solenoids as shown in Fig. 2, one to start the pointer and the other to stop it. The magnets from an electric door bell or buzzer will do as well provided a small iron armature is attached to the arm. The magnets are to be connected in series with a 60 or 100 watt tungsten filament lamp as the case may require. Natural friction will hold the arm in position either in or out. If not, then friction should be provided.

The electric circuit is given in Fig. 3 and shows two plug sockets from which extension cords may be run to the operating buttons or switches.

DEMONSTRATING HOW TALKING PICTURES ARE MADE AND SHOWN, USING ORDINARY VISUAL EQUIPMENT

W. L. Fenner
Hirsch High School, Chicago, Illinois

It is wise to discuss the photoelectric cell and its most valuable accessory, the photocell relay, before beginning this exercise. The telegraph relay offers a simple entrance to the subject of relays in general.

In demonstrating the operation of the photocell relay, a movie projector is a valuable asset and is used in the following manner. Focus the projector on the face of the cell. If the projector is run at a slow speed the succession of flashes will cause the relay switch to click in synchronism with the pulses of light. Varying the speed of the projector varies the speed of the clicks and this leads the student to see that it is the *light* that actuates the cell and its relay. (A flashlight focused on the cell and having its beam interrupted by the blades of a slowly moving electric fan may be substituted for the projector in these demonstrations. Ed.)

Connect a large-window photocell to the input circuit of a high gain power amplifier. (The photocell from the preceding exercise may be used if necessary.) The amplifier should then be connected to a loudspeaker. The sound section of any sound on film projector may be used here. Now if a movie projector is focused on the window of the photocell, and run at slow speed, the loudspeaker will respond with a thumping or humming according to the number of times the beam of light is interrupted by the shutter of the projector. The pitch of the hum rises and falls like the hum of a motorboat and clearly shows the correspondence between the pitch of the sound and the frequency of the pulses of light from the projector. If a neon sign is available allow the light from it to fall on the window of the cell. The pulsating neon light will cause a strong 60 cycle hum in the loudspeaker. If the sign is at a distance from the cell, use a large lens to focus the light onto the window of the cell. (A 2-watt neon glow lamp may be used in place of the sign if a sign is not available. Ed.) As a result of the above demonstration, it is an easy step for the class to see that when the sound track of the film passes between the exciter lamp and the photocell, the markings of the sound track will cause a blinking light to enter the photocell and an audible sound will result in the loudspeaker.

In explaining the method by which speech and music can be transformed into markings on a film, it is assumed that the class understands the principle of the microphone and the effect of the amplifier in magnifying the infinitely small voltages produced by the microphone. Thus any sound generated near the microphone results in a minute electric current which is amplified many hundred thousand times until its voltage becomes high enough to cause a neon tube to glow. The voice frequencies are faithfully maintained and the lamp flickers in exact synchronism with these frequencies. To show this connect a microphone to the input circuit of the amplifier and a small neon lamp (2-watt, Edison base, at about 45 cents) to the output of the amplifier in the place of the speaker. If someone talks or sings into the microphone the lamp will flicker rapidly. When a C tuning fork vibrates before the microphone the lamp will flicker 256 times a second. This fast flickering can be spread out if it is viewed through a rotating mirror. If it is desired a phonograph pickup may be used instead of the microphone.

To show how these flickerings representing sound waves are

transferred to a photograph film, cut a thin slit, vertically centered and near the edge of a square piece of cardboard. Use a lens to focus the light from the neon light on the slit as shown in Fig. 1. While someone talks or sings into the microphone, pull a length of paper tape down the back of the cardboard past the slit. The paper tape represents fresh unexposed film, which passing across the slit is acted upon by the blinking light and the silver reduced. When this is developed the film will show a series of black marks whose intensity and gradation are determined by the loudness and the frequency of the sound. Imagine the neon tube flickering so slowly that pencil lines drawn on the tape at even intervals will represent the result of exposing the film. In actual practice the number of lines would vary from perhaps 80 to 5000 in one second. This demonstration accompanied by

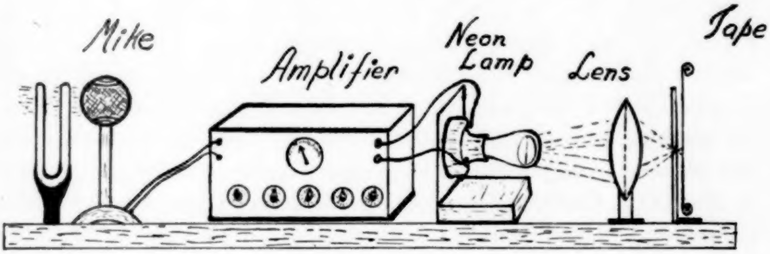

Fig. 1

an explanation of the more difficult parts leaves in the mind of the student a clear picture of the whole process of recording sound on film. A discussion of possible applications and future implications of these principles is then in order.

If an extra amplifier is available set up the apparatus as in Fig. 1 and focus the output of the neon tube on the face of a photocell which is connected to the input circuit of the second amplifier. A speaker should be attached to the output of the second amplifier. Anything said before the microphone is changed to electrical current then changed into light energy in the neon tube, then changed back into electricity in the cell and then back to sound in the speaker. Placing an opaque object between the neon tube and the cell cuts off the sound, clearly showing that the neon light carries the sound by flickering according to the sound frequency.

A SCIENCE TEACHER LOOKS AT THE CLASSROOM FILM

H. Emmett Brown
Teacher of Science, Lincoln School, Teachers College and Instructor in Teaching of Natural Sciences, Teachers College, Columbia University

My experience with the classroom film extends back over more years than I like to recall. Furthermore my interest in the field has manifested itself in the publication of several magazine articles dealing with one phase or another of visual education, and of three compendia of visual materials, two of them done in collaboration. These facts are presented not as a boast of achievement but in earnest of my right to speak out of a long experience with many, many classroom films. For, in spite of my conviction that educational motion pictures constitute an invaluable teaching aid, there are certain features of the films, themselves, and of their production and use, with which I am not pleased. The point-of-view approximates that of the author of the book *Guinea Pigs No More* when, in his chapter "The Consumers' Case Against Business," he draws up a list of 75 indictments (or "gyps" as he calls them) which represent consumer grievances. Although my displeasure is not strong enough to warrant me labeling my points "gyps," let me, nevertheless adopt his technique to the extent of devoting the rest of this article to an enumeration of criticisms of the teaching film, itself, or of certain features of its use. The points made are admittedly not valid of all films, nor of all producers or proponents of visual education—not necessarily true of even a large percentage. They simply represent things that have troubled me at one time or another in my work with educational films.

Criticisms

1. Educators tend to claim too much from the use of motion pictures in the classroom. A number of years ago, it was common to hear that the use of classroom films would effect truly phenomenal savings in the time it would be necessary to devote to the mastery of certain topics, or would greatly multiply the acquisition of knowledge in a given period of time. Today the claims do tend to be more moderate. However the notion is still

prevalent that the use of motion pictures is almost sure to result in a great enhancement of interest on the part of the student, or in a great increase in knowledge, or in both. Actually the opposite is sometimes the case. Thus, it is quite probable that most demonstrations as performed by an experienced classroom teacher, are more effective as teaching devices than the same experiment shown in a motion picture. This was shown to be true in at least one case with silent films,[1] and there is little reason to believe that the situation would be different with sound films.

2. Educators tend to embrace the new in visual education too eagerly. Experiments on the value of the silent film are seized upon and older visual methods tend to be ignored. More recent experiments on the value of the sound film are used as rationalizations for a rush to that type of visual aid, and the silent film tends to be dropped. Actually any well-thought out program of visual education calls for both types of film.

3. Educators and producers, alike, have failed to face the fact that for a program of visual education using motion pictures to function successfully the films should be owned by individual schools, or by small groups of schools in a given community. For the best results from a teaching film the teachers should be able to show a film (1) when, and only when it really fits and (2) as often as it seems desirable. These conditions usually cannot be realized when it is necessary to rent the film.

4. Too many films are produced that fail to take recognition of the fact that the unique function of a film is to show motion. Years ago I saw a motion picture, an educational picture, if you please, which took the observer on a trip to an art gallery. Many feet of film were devoted to "stills" of certain paintings. The only motion in the picture was the sweep of the camera from one picture to the next, and the movement of people in the gallery—both extraneous to the theme of the picture. We do better today but it is doubtful if such films as *Illumination* and *New York Water Supply* are exemplifying this function at its best. The alternative? The same scenes in slides—or demonstrations of the principles involved.

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[1] The experiment reported by E. C. Rolfe in chapter IX "A Comparison of the Effectiveness of a Motion-Picture Film and of a Demonstration in Instruction in High School Physics," in Freeman. F. N. *Visual Education*.

5. Many films tend to try to cover too much ground—to be too inclusive. This is often true of some of the newer films specially produced for school use and which in other respects may be excellent. Thus in one of the Erpi films, *The Solar Family*, the following topics are covered:

the evolution of the solar system according to the planetesimal hypothesis,
the real and apparent motion of the planets,
the phases of Venus,
the retrograde motion of Mars,
Jupiter and its satellites,
the apparent motion of Saturn's rings,
orbits of the planetoids, Eros and Anteros,
orbits of Halley's comet,
the motion of the solar system in space.

And this all in one reel. Naturally the film hurries from one topic to another with breath-taking speed, and the observer feels a sense of strain.

In the film, *Jewels of Industry* we are supposed to see how carborundum and aloxite are made, each by a different process and to learn of the many uses of these abrasives—all of this in one reel, also.

6. Films are often too general. This is often true of free films put out by commercial concerns in which you are taken on a trip to their plant or are shown how their product is made, or used. Thus in the film, *Eyes of Science*, after a first portion that shows quite nicely how lenses, mirrors and prisms may be used to control light, and how optical glass is made and lenses ground the film goes on to a final reel in which the uses to which the various optical devices the company makes are shown in such a way as to have little of either appreciational, or informational value.

7. Educational films are often downright dull (although classroom films have no mortgage on hebetude, by any means). In this class I would place that series of silent films, dealing with geographical topics, which were essentially chalk talks. In the same category I would place the Eastman film, *Weather Forecasting*, which, although it contains some good footage on the movement of highs and lows across the country (see point 13) nevertheless has some dreary sequences on the making of meteorological measurements.

8. In many films there is not good balance between the right amount of detail, and too much, or too little. Thus, in the DuPont film *The Wonderworld of Chemistry* we are shown the raw materials from which various products are made. We get an impressionistic flash of test tubes and other apparatus and then—Behold!—the finished product. The character and purpose of the film would obviously preclude detailed depiction of manufacturing methods. However observers would welcome some general indications of types of processes. An attitude of amazement cannot be maintained indefinitely.

Take another case. Because it is the maker of the electric motor used in its icing unit, the General Electric Company in its film, *How the General Electric Company Icing Unit Works*, shows, not only the principles by which the refrigerating mechanism operates (a good job, by the way) but also, and quite unnecessarily in my opinion, the principles involved in the working of the motor.

9. Films are frequently teleological in their explanations. This is frequently true of nature study films when they impute purpose to the instinctive behavior of animals, and to certain natural phenomena. In a different category, but still equally culpable, is the new British sound film, recently released in this country, called *Fingers and Thumbs*. This film deals with the evolutionary development of man's hand. At several places in the film the commentator implies that evolution took place in a certain way in order that the animal may be able to do certain things, an implication of purpose in the evolutionary process that scientists generally would reject.

10. Films are often inaccurate. Small inaccuracies are bound to creep into films just as they do into books. These are to deplored, of course, but they are not as bad in their effect, as the kind of error represented by films which present scientific theories as established facts. *Fingers and Thumbs* made that sort of error. So, too, did the General Electric film, *Beyond the Microscope*, when it presented the Langmuir theory of the atom, and the molecular theory of matter, with little to indicate their hypothetical character.

11. Films often fail to stress the imaginative and inspirational side of their material. In a way this is an expansion of point 7, and may be the result of the failing noted in point 5. Thus the Erpi film referred to in point 5, and others in the Erpi astron-

omy series, are so concerned with getting the facts and theories of astronomy before their audience, that they fail quite completely to paint an imaginative picture of the deep vastnesses of space, and the immensity of time.

12. Films are often guilty of small, but irritating technical errors or omissions. Thus in the two Erpi pictures dealing with sound phenomena (*Sound Waves and Their Sources, Fundamentals of Acoustics*), which in many ways are excellent, the following errors occur:

a. The music of an orchestra heard in the picture is not in time with the conductor's beat,
b. The music of a marching band is not in time with the step of the marchers,
c. A woman is heard singing but, at first, her lips are not in motion. When they do begin to move, they do not do so in accordance with the words she is supposed to be singing.
d. The echo of a bugle call is not the same as the original call, the echo being marked by a very definite break not present in the original.

There may be other errors but these are the ones that bother me after a lapse of several months.

13. Films often do not employ the animated drawing to the best advantage. This is often true of films which show trips through industrial plants, or manufacturing processes. The U.S. Bureau of Mines film *Story of a Storage Battery* uses animation only to show the process of charging and discharging a storage battery. The animation is badly needed to make clear the previous manufacturing processes. The General Electric film, *Illinois Central Locomotive No. 11,000*, has many shots of the locomotive in use but none to make clear how it is built or how it works.

14. Films are often guilty of poor photography. Examples of this were all too common with both free and rental films of a few years ago. Industrial films were often the worst offenders. Today this fault is less common, although it still pops up occasionally to bother us. Instead we are likely to find photography which does not too cleverly conceal the use of models (The Erpi film, *The Moon*) or which lacks in pictorial quality or beauty. Theatrical films which have been adapted for school use are likely to be better in this respect.

15. Films often use human actors in such a way as to be troublesome. Thus in the silent film, *Through Life's Windows*, on the occasion that I saw it last, the costumes of the people were so outmoded as to provoke laughter. In the Bureau of Mines' film, *The Evolution of the Oil Industry*, the first reel has scenes from the early picture, *Intolerance*, in which the tarring of the Ark and the use of burning oil were shown. Again there was laughter from the high school group witnessing it—this time because of the outmoded style of screen acting. Perhaps the worst example of this fault is that rather horribly precocious lad in the Bell Telephone Laboratories film, *The Voice of Science*, to whom the scientist is explaining the action of the artificial larynx and who ejaculates (no less artificially), "Oh, boy! I'm learning things today!" And this after he had just finished a song in the worst Bobby Breen manner!

16. The advertising in films is sometimes objectionable. I well remember an early International Harvester Co. film in which the use of some that of that company's tractors were shown. Every few feet, as it seems to me now, there would be a vignetting down of the picture on the screen, until the oval at the center of the screen revealed an enlargement of the company emblem. Today few films are so blatant. They "get us" today with their footage which exaggerate the great care taken in the manufacture of their product and the numerous tests to which raw materials and finished product are subjected. A flagrant example of this practice was afforded by the Irvin Air Chute Co. film, *Happy Landings* which devotes almost all of the second, final, reel to this sort of material.

17. The titles of films are often misleading. Who would guess, for example, that *Mighty Atoms* deals with microscopic insects, or that *The Romance of Glass*, after devoting a little space to the historical discovery of glass and a little more to the modern manufacture thereof, would then plunge into a canning demonstration?

18. Some film titles, or subtitles, react unfavorably on the high school audience. In this class I would place the plenitude of film titles that begin with "The Romance—." That is, such titles as *The* ROMANCE *of Glass*, *The* ROMANCE *of Oil*, *The* ROMANCE *of Rayon*—all titles of actual films. In this same category are, *The* AMAZING *Vitamins* and *Mount Rainier's* GLORIOUS *Glaciers*. In short, any title which in effect says, "Isn't this

wonderful?" will probably evoke antagonism from high school students.

19. Some educational films are theatricals which have been released for school use without adequate preparation or editing. In this class I would place the film *Mysterious Forces* for which, years ago, I prepared a teaching manual. At that time I recommended that the company lay rather drastic hands on the film—retake some scenes, eliminate some, make some new scenes, and change the title. Beyond shifting some of the scenes a bit, nothing was done. While the material in this film was suitable for theatrical purposes, it is culled from too many science fields to be valuable for teaching purposes. In this connection teachers should bear in mind that a film may serve either of two purposes—supplying information, or developing appreciations. Any film that serves one of these functions well, will probably not do as well by the other.

20. Educators and producers need to think through the problems raised by the issue of silent versus sound films. As suggested in point 2 there seems to be a rush now toward the sound film. Admittedly sound is excellent for many purposes. For some things that it does the silent film would be badly unsuited (obviously the presentation of the phenomena of sound, for example). For other purposes the silent film may be better. In addition to considerations of the merits of the media, the following practical points relating to use also have bearing:

a. The silent projector is at once cheaper, easier to operate and less cumbersome.
b. Most, if not all sound projectors, are not equipped to give still pictures of individual frames.
c. Sound pictures cost more than silent, either to rent or to purchase.

21. On certain sound films, the speech is of poor quality of reproduction, or is poorly adapted to the use for which the film is intended. Thus in the film, *Galileo's Telescope* and *Mt. Wilson Observatory* the speaker talks too fast. Reducing the speed of the film to slow him down to comprehension limits, causes his voice to become badly distorted. In the Erpi picture *Molecular Theory of Matter* the speech sometimes seems to get in the way of thought. As one student put it, "You wish the speaker would 'shut-up' and let you think." The argument advanced by pro-

ponents of sound that in such cases you can operate the film as a silent picture seems to me beside the point.

22. Musical backgrounds are often a problem with sound pictures. Particularly with those theatrical pictures which have been adapted for school use, there is likely to be a musical background which extends even through speech. This may, or may not, be a bad distraction depending upon the subject of the film and the relative importance and difficulty of the thought conveyed by the speech. Certainly one may well question the value of such musical accompaniments if employed continuously throughout an educational film. On the other hand, many sound films that have been developed for school use, do not use musical backgrounds at all. Perhaps because of their movie theater experience, most persons miss these backgrounds. The solution may be to have a musical introduction and conclusion to all films with only slight and judicious use of musical accompaniment within the film proper.

23. With the advent of the sound film, many producers began to make over their old silent films merely by the addition of running commentary. This needs to be done carefully in order that the values of the silent film be not reduced in the process. In every case producers should be able to demonstrate the improvement in the film made by the addition of the sound. Else why add the sound at all?

24. In certain areas where there is intense commercial rivalry there are numerous duplicating films. Thus in my visual file under "Oil Refining" I find cards for 14 different movies—and this by no means necessarily represents all that might have been listed. Similar conditions exist for a few other areas, e.g. the automobile. Such duplication is unnecessary. It may be a realization of this fact that has lead the Union Oil Co. to put out films such as *The Tree of Life*, dealing with evolution, and has caused the Chevrolet Motor Co. to distribute films not immediately concerned with automobile manufacture. The new point-of-view with respect to advertising and the existence of coordinating agencies among manufacturers should reduce the amount of duplication of film subjects in the future.

25. Teachers' manuals designed for use with educational films are often of less than optimum value. They usually are adequate in providing a summary of the film, sufficiently detailed

to make a preshowing of the film unnecessary. They usually have supplementary references which are helpful, also. They are deficient, however, in that they fail to provide more complete aids for the use of the film and detailed suggestions as to how the teacher may evaluate the results thereof.

26. It is still too hard for the average teacher to find out just what films are available and where they may be obtained. I say this in spite of the existence of a number of compendia of educational films. They all stop short of completeness. *1001*, the film directory put out by the magazine, *The Educational Screen*, attempts, each year, to list all the 16mm. films, but fails to give adequate descriptions or to classify films in such a way as to be of maximum use to a science teacher. The new film catalog of the H. W. Wilson Company augurs well for the future. However, as yet it has no single publication that contains all the good available films. Its catalog is issued along the same line as the *Reader's Guide to Periodical Literature* (also published by the Wilson company) and only lists films that have been released since the last revision, or earlier films whose listing should be changed in some fashion. The descriptions of films, classified according to the Dewey decimal system, are generally detailed and complete, but have been deficient as to giving all the sources from which a given film may be obtained. What is most needed, in my opinion, is a service by which teachers can secure a printed list of the names of all of the films, classified by subject, from which list he may order $3'' \times 5''$ printed cards, which describe the film completely, evaluate it for school use, and which give all the sources from which the film may be obtained. From these cards any teacher can build his or her own visual file.

27. Projectors are still, by and large, too expensive and too cumbersome. In these days of stream-lined trains and light-weight alloys it should be possible to design a motion picture projector that would be at once stable, light in weight, efficient, easy to operate, and cheap. At the present time the situation with the sound projector is such that this factor looms large in retarding the growth in the use of talking films in the schools. Cost is probably the main cause for schools having but one sound projector although each department may have its silent projector. Even where cost is not an item, the inconvenience of setting up the sound projector often causes its use to be limited to the school auditorium, a place where films should not be

shown for teaching purposes. A single, self-contained, light-weight machine is needed. This probably means that projection must be from the rear of the screen, as in many news-reel theaters.

As I look back over these various points, I am concerned lest any reader of these fragmentary notes jump to the conclusion that because a film from a certain company is criticized in a certain connection, the film is necessarily all bad, and that other films from the same source are to be condemned in the same way. Such conclusions are not justified. For every film that I have singled out for criticism there are probably many other films from a number of different sources to which the same criticism is equally applicable. If I have mentioned the films of certain companies more often than those of other producers it is not because of discrimination but because I know their films more thoroughly. In the reference to some films the producer's name is not given. These are usually the older films for which it is sometimes difficult to determine the original producer.

A NEW TYPE OF TEST IN CHEMISTRY

Ralph E. Wellings
Dorchester High School for Boys, Boston, Massachusetts

Various types of tests have supplanted, to a great degree, the older tests composed entirely of information-seeking questions. Today, we agree that information can be tested more efficiently by such a device as the "completion test." If we wish to test for knowledge of laboratory technique, we use the "what is wrong?" test, employing pictures of laboratory or demonstration set-ups in each of which one or more errors appear. To test problem-solving ability we use problems involving small integers in order that many answers may be obtained in a short class period.

These "new type" tests enable us to ask many more questions in, say, a half hour, and they have the advantage of being easy to correct. They are subject to two drawbacks, however, neither of which militates against the extensive use of these tests. First, they eliminate lengthy answers, depriving pupils of practice in expressing scientific facts and conclusions in carefully chosen words. Second, they encourage the practice of guessing the answers on the part of nearly all pupils.

There is another type of test, seldom used, but which the author has employed with varying success for the past five years. This test may be called the Historical Experiment Test. An actual experiment, performed long ago by some famous chemist, is given to the pupils, together with one or more questions to be answered concerning it. For example, we may choose an experiment dealing with the oxidation of a metal. In 1673 Robert Boyle heated tin in a glass retort and, when the tin melted, sealed off the neck and continued the heating for two hours. Then the retort was allowed to cool and the sealed tip broken off. Concerning this experiment we might require answers to the following questions:

1. Did a chemical change take place in the retort? Explain.
2. Did any change take place in the retort after the neck was sealed off? Explain.
3. Why did Boyle continue the heating after sealing the flask?
4. When the tip was broken, what happened?
5. Did the tin gain or lose weight? Why?

If three historical questions similar to this one are mimeographed on a single sheet and a copy handed to each pupil, we have a very satisfactory test that is, perhaps, unlike any the pupil has ever seen.

What are the advantages to the pupil to be derived from such a test? First, guessing is practically eliminated. Second, the pupil is compelled to use his imagination to reconstruct the experiment as originally performed. We may even require a drawing of the set-up just after the heating was completed. Third, the application of acquired factual knowledge to an experimental problem will be valuable practice for all students. Fourth, to apply knowledge in a specific instance requires the exercise of the reasoning faculty. Fifth, a knowledge of the ingenuity of the famous chemists of the past in devising experiments leads to a deeper appreciation of these men. Such tests may be made the starting point in the study of the history of chemistry or may motivate some pupils to read popular or encyclopedia accounts of the famous chemists of the past. Sixth, the appearance of the word "explain" forces the pupils to express their opinions more at length, affording some practice in self-expression. Seventh, the whole test may be made the center of an oral exercise. This would give much needed practice in oral expression and perhaps lead to discussions which will be very beneficial, if properly directed by the teacher.

No doubt, the reader will be interested in a few more examples of such historical experiments.

A. In 1667 John Mayow inverted a large glass globe over a lighted candle standing in water. The water rose inside the globe. When the flame died out, a large bulk of gas was left.

1. Diagram this experiment at its conclusion.
2. Diagram this experiment at the instant the globe, inverted over the candle, touched the water.
3. Why did the water rise inside the globe?
4. Was anything added to the gas left in the flask?
5. Why did the flame die out?
6. Did any chemical change take place in the experiment? Give a reason for your answer.

B. In 1673 John Mayow found that gunpowder rammed into a paper tube and ignited continued to burn under water. Explain.

C. Carl Wilhelm Scheele caused a hydrogen flame to burn under a glass globe standing over hot water. The water at once began to rise until one-fourth of the flask was full, when the flame disappeared. Remembering that nothing rises by itself against gravity;

1. Explain why we say the water began to rise.
2. What is your conclusion from the words "until one-fourth of the flask was full"?
3. Why was hot water used?
4. Do you think that the gas or gases remaining in the flask would support combustion? Give your reason.

D. Carl Wilhelm Scheele noticed the contraction of a confined volume of air standing in contact with various materials such as iron moistened with water.

1. Did the air contract or was some of the air actually removed from the container? Give a reason for your answer.
2. If this experiment was performed over water using an inverted cylinder containing iron filings, what would happen to the water? Why?

E. Scheele heated some zinc to redness and it burned with a brilliant flame. He concluded that phlogiston escaped.

1. Would you conclude that the air contained phlogiston?
2. If you performed the experiment and weighed the white residue, do you think it would weigh less than the original zinc used? Give a reason for your answer.

SUGGESTIONS FOR THE CARE OF PETS IN THE ELEMENTARY SCHOOL CLASSROOM

David W. Russell
National College of Education, Evanston, Illinois

[Editor's Note—This is the second of a series of four articles of practical interest to elementary science teachers. The first article, "Adding Interest to the Elementary Science Classroom," by Dorothy V. Phipps, appeared in the March issue and described the construction of aquariums, terrariums, vivariums, and other classroom equipment. The third article will appear in the May issue and will tell about interesting science activities in the primary grades.]

The care and handling of pets is one of the most popular science activities in the elementary grades. Most teachers will agree that when there are pets in the classroom, enthusiasm prevails and interest seldom lags if the pets are not kept too long. The following outline is intended to serve as a ready reference for teachers who are often unexpectedly confronted with the problem of caring for a pet that has been brought to school by one of the children. Whether it is a snake or a white rat, moth or crayfish, the living creature must have immediate attention and while pets are usually "cared for by the children," the care must be under teacher guidance if the pet is to have a square deal. The material in this outline is based upon practical classroom experience and is not intended to be a biological treatment. The outline is followed by references that have been helpful in making this summary and are suggested as additional sources of information on the care and handling of classroom pets.

ANTS

I. Feeding
- a) Provide bread crumbs, broken rice, a little honey or sugar, crumbled nut meats.
- b) Dead insects or spiders, bits of raw or cooked meat, bits of hard-boiled yolk of egg.
- c) Seeds of plants, grasses, and berries and fruits of many kinds.

II. Housing
- a) Nests can be made or purchased.
- b) A tumbler half full of "ants' nests" and as many ants from colony as possible.
- c) Place tumbler in saucer and pour water around it.
- d) Wrap dark cloth around tumbler and remove only when observing.
- e) Place paper box one inch square and ½ inch high on nest. (Ants use this for refuse.)

III. Habits
- a) Breeding

1) Males and queens stay hidden underground until marriage flight.
2) Males return to die. Queens may return to start a new colony or leave for same purpose.
3) Queens lay eggs in underground chamber.
4) Eggs to larvae to cocoon to young ant stage cared for by "nurses."

IV. Temperament
a) Very sensitive to light.
b) Formicary placed in room with red light is less disturbing to ants.

V. Classroom Comments
a) Ants can be studied with microscope or hand lens.
b) Easy to observe, always active.
c) Very interesting to children.

THE BAT

I. Feeding
a) Most kinds of insects.
b) Bits of raw meat (substituted).
c) Fresh milk.
d) Place fresh water where bat can find it.

II. Housing
a) Glass sided box with wire top.
b) After the bat is tamed, provide a place for it to hang or keep in dark box during the day.
c) Keep in room where it can fly about at night.
d) Keep in cool protected room during the winter as it hibernates.

III. Habits
a) Breeding
1) Mates in the spring.
2) Babies, usually twins, are born in July.
3) Mother feeds her young.
4) Young cling to mother's neck when she hunts insects.
5) Mother hangs babies on twigs where they are trained to stay until she returns.

IV. Temperament
a) Responds to kindness.
b) Learns to take food from master or mistress.
c) Does not like strangers.
d) Wings are very sensitive and it resents having them touched.
e) Delights in having back scratched with bit of wood.

V. Classroom Comments
a) May nip and bite and can inflict quite severe wounds.
b) Do not keep where it can't fly around.

BUTTERFLIES, MOTHS, CATERPILLARS

I. Feeding
a) Caterpillars
1) Experiment with green leaves, grasses, cabbage until one is found that it accepts.
b) Butterflies
1) Leafy twigs and branches in terrarium.
2) Thistles, clover, honeysuckle, nasturtium, and goldenrod.
3) Fresh thick syrup of sugar and water every morning.

c) Moths
 1) Have poorly developed mouth parts and may not eat,
 2) Like foods mentioned above for the butterflies.

II. Housing
 a) Can be placed in terrarium.
 b) A box large enough to allow for plenty of twigs and foliage.
 c) Wire cage of fine mesh.
 d) Cover top or caterpillars crawl out.

III. Habits
 a) Life History—Four Stages
  1) Eggs
   a) Tiny brownish spheres laid by adult.
   b) Ten to fourteen days to hatch.
  2) Larvae—Caterpillar
   a) Begin to eat at once.
   b) Build cocoon.
  3) Cocoon or chrysalis, etc.
   a) Fastened to twig where it sleeps all winter.
  4) Adult
   a) Emerges in spring.
   b) Takes about fifteen minutes or more to change to moth or butterfly.
   c) If kept too warm, will emerge before there is green food.
   d) Adults usually short lived.

IV. Classroom Comments
 a) There are no dangers connected with the butterflies.
 b) Fascinating study for children.
 c) Easily cared for.

THE CANARY

I. Feeding
 a) Mixture of seeds: grass, millet, hemp.
 b) Some green food daily: lettuce, tender grass.
 c) Winter food: sweet apples, slice of orange, potato or carrot, cabbage leaf.
 d) Special food given during molting season.
 e) Have grit of some sort always accessible.
 f) Cuttle-fish bone.
 g) Fresh water, daily.

II. Housing
 a) Large oblong cage to permit exercise.
 b) Larger cages furnished for breeding.
 c) Removable tray on bottom of cage.
 d) Perches placed conveniently to food and water.
 e) Keep sand or paper on floor.
 f) Hang cage in the light but not in a window.
 g) Cover cage at night when left in schoolroom
 f) Set cage in quiet part of room when it first arrives.
 i) Only go near cage when necessary for feeding and cleaning.
 j) Renew the sand in cage twice daily.
 k) Clean the perches every day or two.
 l) Wash and fill water cups daily.
 m) Wash the food cup often (blow off husks before refilling).

III. Habits
   a) Breeding
      1) Provide larger cage, nesting materials, and give special food and care.
      2) Best breeding: male one year old and female two years old (preferably not from the same family).
   b) Let them build nest, don't disturb.
   c) Canary lays from one to five eggs.
      1) Twelve days for five eggs.
      2) Eggs are hatched in order laid.
   d) Parents feed and care for young.
      1) Take care of themselves at two months.
      2) Begin singing at three months.
      3) Fairly good singers at four months.
      4) Very good singers at nine months.
      5) The average age of bird is eleven years.

IV. Temperament
   a) The canary is easily tamed and becomes friendly.
   b) Will chirp replies to spoken words.
   c) Lively and happy.
   d) Will sing while others sing.
   e) Has no objection to activity.
   f) May be startled by sudden movements.

V. Classroom Comments
   a) Hardy, but sensitive to draughts.
   b) Subject to many diseases and parasites.

THE CAT

I. Feeding
   a) Feed at regular periods.
   b) Bread and milk.
   c) Potatoes mixed with meat scraps and gravy, occasionally.
   d) Fish heads or scraps.
   e) Raw meat on bones to chew on (not small chicken or game).
   f) Cooked meat in reasonable quantities, daily.
   g) Porridge in winter months.
   h) Likes grass, mint, and catnip.
   i) Keep dish of clean water always.
   j) Kittens are taught to lap milk and eat solid food after mother weans them.

II. Housing
   a) Provide box or basket for sleeping.
   b) Make bed of soft straw or hay with disinfected sawdust underneath.
   c) Carpet or cushion may be used.
   d) Place the bed in warm location.
   e) Do not put out at night.
   f) Cats do not do well in pens or cages.
   g) Shallow tin of earth or ashes for elimination purpose.
   h) Change bedding often.
   i) Clean the carpets or cushions often as they may become infested with fleas.
      1) Wet fur with solution of one quart of water to two tablespoons creolin.
      2) Tar soap can be used for washing cat.
      3) Spray fur and bedding with spirits of camphor.

j) Wash cat's dishes daily.
k) Empty elimination box daily.

III. Habits
a) Breeding
1) Time from conception to birth is nine weeks.
2) When the young are expected, mother should have a dark and quiet retreat.
3) Provide open basket with soft carpet.
4) Supply all milk she can drink.
5) Usually two to five kittens in litter.
6) Mother feeds, washes, and cares for kittens.
7) Leave kittens with the mother until she tries to wean them (five to seven weeks).
8) Kittens reach maturity in nine to twelve months.

IV. Temperament
a) Very sensitive to treatment, responds to good care.
b) Very affectionate, can be petted.
c) Will mew, purr, howl, or "spit" according to how the cat feels or is treated.
f) May carry disease.
g) Apt to scratch or bite if mistreated.
h) Cannot be confined.
i) May be a source of disturbance in schoolroom.

V. Classroom Comments
a) May be left to wander around the classroom or building.
b) Do not allow children to handle it very much.
c) Cats keep themselves clean. (Long-haired variety should be bathed.)

THE CRAYFISH

I. Feeding
a) Bits of meat, liver, fish, two or three times weekly.
b) Food attached to strings and removed before too stale.

II. Housing
a) Keep in aquarium with three inches of gravel at bottom, slanting to within an inch of surface of water.
b) Only three or four inches of water.
c) Abundance of pond weed.
d) Needs much oxygen.
e) Take care of aquarium as for any fish.

III. Habits
a) Breeding
1) Eggs laid in November or December and glued to abdominal legs of mother.
2) Hatch from May to July.
3) Young miniature replicas of parents.
4) Build caves or nests to hide in.
5) If any legs or antennae lost, will grow again.

IV. Temperament
a) Very interesting to watch.

THE CRICKET

I. Feeding
a) Gets most of its food from the soil.
b) Small particles of bread can be given once a week.

II. Housing
- a) A box containing several inches of earth.
- b) A warm place 70 to 80 degrees F.
- c) Two glass sides desirable (for observation).

III. Habits
- a) Female lays about 150 eggs in the fall.
- b) Eggs remain in the warm soil about six months before hatching.
- c) When hatched, young are ½ inch long and are light brown.

IV. Temperament
- a) Friendly.
- b) Chirps when things are quiet.

V. Classroom Comments
- a) Not objectionable.
- b) Children enjoy watching them.

THE FROG

I. Feeding
- a) One large meal once a week is sufficient.
- b) Insects of all kinds.
- c) Earthworms—mealworms.
- d) Raw liver may be used constantly during the winter.
- e) Feed mosquitos and earthworms to tadpoles.

II. Housing
- a) An aquarium jar—square or oval covered with wire netting.
- b) Bottom covered with gravel sloping up to dry land on one side.
- c) About three inches of water over shallow gravel.
- d) Flat stone or moss planted to use for landing place.
- e) Change the water once a week.
- f) Change the water day after feeding.

III. Habits
- a) Eggs laid in globular masses of pale green jelly surrounding twig or stem, near pond.
- b) Care of eggs:
    - 1) Place eggs in flat dish containing three or four inches of water and algae.
    - 2) Set the dish on table receiving sunshine part of the day. Keep away from artificial heat.
    - 3) Remove dead eggs (white) at once. They pollute the water.
- c) Tadpoles begin to wiggle through jelly.
    - 1) Place the aquarium with sand and water plants.
    - 2) Require about four months to mature.
    - 3) Put support in water for them to crawl upon, when they begin to come up for air.
    - 4) Cover container with glass or they may disappear.
- d) Frogs hibernate in mud during the winter.
- e) Shed coat in spring.
- f) Do not keep bullfrog in tank with smaller creatures.

IV. Temperament
- a) Become very tame.
- b) Like petting and handling.
- c) Can be fed by hand.
- d) Interesting habits.

V. ClassroomComments.
- a) They are harmless and make engaging pets.

THE GARTER SNAKE

I. Feeding
  a) Small frogs and toads killed first and then presented on stick in lively manner.
  b) Can subsist almost entirely on earthworms.
  c) Feed once a week.
    1) Snakes often refuse food for two or three weeks, without harm.
  d) Fresh water must be given every day.
    1) Place in small enameled pan ($4'' \times 3'' \times 2''$).

II. Housing
  a) Cage or Vivarium, $18'' \times 8'' \times 12''$, serves four or five garter snakes.
  b) The bottom and three sides of wood, one of glass.
  c) Cover bottom with pebbles, sphagnum moss, and slabs of bark (for retreat).
  d) A small branch fixed to provide basking place.
  e) Cover of wire screening hooked in place to prevent snakes from prying it open.
  f) When changing water, look for excreta.
  g) Remove with dull putty knife.
  h) Wipe wood with damp cloth.
  i) Place cage in window but provide some shade.
  j) During hot weather, keep in cool place but let them bask in sunshine during portion of day.

III. Habits
  a) Breeding
    1) The young are six inches long at first and are born late in July.
    2) Eleven to fifty in brood.
    3) Mother remains with young till fall.
    4) Find own food immediately.
  b) Snake hibernates in northern climates during winter.

IV. Temperament
  a) Becomes very tame and friendly.

V. Classroom Comments
  a) These snakes are harmless.
  b) Give off a secretion if attacked or frightened.
  c) Odor of secretion is very disagreeable and persistent.

GRASSHOPPERS

I. Feeding
  a) Green grass growing in the house.
    1) Must be kept moist.
  b) Like celery and over-ripe bananas.

II. Housing
  a) Glass jar containing layer of moist soil covered with sod.
  b) Box with grass seed planted in it can be prepared in advance.

II. Habits
  a) Lay eggs in soil in autumn.
  b) 30 to 100 or more eggs deposited in masses enclosed in capsule.
  c) Eggs hatch in spring after warm weather comes.
  d) Little grasshopper (nymph) like the adult without wings.
  e) Wings appear soon, grow rapidly.

IV. Temperament
  a) Friendly.

V. Classroom Comments
  a) They are not objectionable and the children find them very interesting.

GUINEA PIGS (Cavies)

I. Feeding
  a) Anything of vegetable nature.
    1) Carrots, lettuce, clover, parsley.
  b) Sweet hay should be within reach.
  c) Evening meal mixture of bran, meal, oats, barley, or rice made just moist enough to stick together.
  e) Bread and milk squeezed almost dry can be given in the morning.
  f) Always have fresh water within reach.
    1) They do not drink much.
  g) Don't overfeed. Give just what they'll eat.
  h) Change the diet every few days.
  i) Regularity of feeding important.
  j) Place food and water in flat dishes to prevent tipping.

II. Housing
  a) Cage need not be large. Cavies are not very active.
  b) Hutches. Does and bucks over five or six weeks old should be separated.
  c) Large box with wire netting over top may be used.
  d) Smaller box inside with hole on one side for sleeping quarters.
  e) Movable zinc tray for bottom, desirable.
  f) Sloping stairways, extra entrances, and passages amuse animals.
  g) Keep cage clean and dry. Very important.
  h) Change bedding once a day and renew the hay, straw, shavings, or dry sand every few days.
  i) Cleaning fluid to be used is one gallon of water and eight tablespoons of creolin.
  j) Coat inside of the cage with white wash or creolin.

III. Habits
  a) Breeding
    1) Very prolific.
    2) Breed at very early age.
    3) Young will be stronger and better if male and female are kept apart until eight or nine months old.
    4) Remove the male before the young are born. He may eat them.
    5) Do not handle young until they are covered with hair.
    6) Litters every two months.
    7) Young should be left with mother until they eat solid food, four or five weeks.
    8) They usually have two or three young at once.
    9) Squeak and chatter a great deal.
    10) Afraid of open spaces.
    11) Keep only one male in a cage at any time.

IV. Temperament
  a) Among most appreciative, friendly, and satisfactory of all pets.
  b) Docile, quiet, good-natured and neat.
  c) Sensitive and suspicious about being touched, especially by strangers.

V. Classroom Comments
  a) They are free from vermin.

b) Not subject to disease or parasites of any kind.
c) They require much care in feeding, housing, cleanliness.
d) Very sensitive to temperature changes.
e) They must be kept warm.
f) Easily injured if picked up by the skin as kittens.

THE PARROT

I. Feeding
a) Mixture of hemp, sunflower seeds, unhulled rice and cracked corn.
b) Ripe fruit such as bananas, oranges, cherries, apples.
c) Cuttle bone to nibble on.
d) Fresh water two or three times daily.
e) Do not feed fish, or bread soaked in milk.
f) Never feed meat, or grease.

II. Housing
a) Use galvanized flat top wire cage—never brass.
b) Have perches, rings and other playthings in cage.
c) Have the door sliding and the food dishes removable from the outside.
d) Remove drinking dish as soon as bird is through.
e) Give the bird opportunity to take bath outside of cage.
1) Gray parrot prefers dust bath.
f) Place cage in warm room where there are no draughts.
g) Always keep cage in same place.
h) The cage must be cleaned daily.
i) Floors covered with clean white sand or dried soil.
j) Keep food dishes very clean and scald often.
k) No food remnants allowed in cage day after given.

III. Habits
a) Pairs remain mated for life, which is long.
b) Incubating period twenty-four days.
c) Young cared for by the parents.

IV. Temperament
a) Very tame.
b) Never forgets people who annoy it.
c) Has strong likes and dislikes.
d) Playful.

V. Classroom Comments
a) May chatter incessantly.
b) Subject to disease and parasites.
c) Sensitive to temperature.

THE PIGEON

I. Feeding
a) Food placed in hoppers.
b) Feed dry grains, hemp or rape seed, small field peas, and crushed corn.
c) Likes tender green food: lettuce, onion tops.
b) Must have salt.
e) Have crushed oyster shell and charcoal available.
f) Give the pigeon plenty of water at all times in small basin or the birds will bathe in it.
g) Do not feed barley or rye.
h) Large kerneled corn may choke bird.

II. Housing in School
   a) Coop, box or cage $4' \times 4' \times 4'$.
      a) Keep a pair only short time for observation.
   b) Inside cage should be whitewashed with lime.
   c) Cover the floor with sand, sawdust or chaff.
   d) Must be rat proof.

III. Habits
   a) Breeding
      1) Breed all year round except when molting.
   b) Hen pigeon lays two eggs usually with one day between
   c) Hen and mate alternate setting on eggs.
   d) Incubation is sixteen or seventeen days.
   e) Squabs fed and cared for until five weeks old.
   f) Cannot stand confinement.

IV. Classroom Comments
   a) They have an odor.
   b) They are not dangerous.

THE RABBIT

I. Feeding
   a) Should be fed twice a day, morning and evening.
   b) Vegetables in the morning.
      1) Beets, carrots, lettuce.
      2) Clover, grass etc. Be sure the greens are dry.
   c) Grain or whole oats in evening.
   d) Hay should be kept in hutches.
   e) Feed dry bread or bread and milk for nursing mothers.
   f) Warm mashes of potatoes, bran, etc., can be served in cold weather.
   g) Give the rabbit plenty of drinking water.
   h) Do not overfeed.
   i) Feed young rabbits very sparingly.
   j) Never feed wet food.
   k) Indoor pet rabbits should never be given cabbage.
   l) Fasten water vessel securely to prevent spilling.

II. Housing
   a) Hutch ($6' \times 2' \times 2'$) or open cage ($3' \times 1\frac{1}{2}' \times 1\frac{1}{2}'$).
   b) Opening at top and side for cleaning.
   c) Removable zinc tray or floor desirable.
   d) About $\frac{1}{3}$ of pen partitioned off for sleeping quarters.
   e) Use hay, fine straw, or clean dead leaves with sawdust under it for bedding.
   f) Cage can be raised from floor and put on rollers for easy moving.
   g) Galvanized iron wire nailed inside wooden frame prevents gnawing.
   h) Have runways for exercise.
   i) Keep the cage clean and dry.
   j) Wash the zinc trays daily with soap and water.
   k) Place newspaper on the tray but remove and burn daily.
   l) Handful of "Sanitas" keeps down odor.
   m) Remove all foodstuffs not eaten.

III. Habits
   a) Breeding
      1) Keep the does and buck apart until six to ten months of age.

2) Mate old does in February and the young ones in March.
3) Breeding hutches should be thoroughly cleaned and disinfected.
4) Pregnant doe must be kept private and quiet.
5) Doe carries young about thirty days, makes own nest.
6) Do not disturb after litter arrives. She may devour them.
7) Do not remove the young until two months of age.
8) After weaning, separate the sexes.

IV. Temperament
a) Friendly.
b) Stands considerable mauling and petting.
c) Hold and lift by the neck, supporting the hind quarters, never lift by ears (sensitive).
d) Becomes very tame if treated kindly.
e) Not affected by cold weather.
f) Mother's care of young interesting.

V. Classroom Comments
a) Subject to diseases.
1) Common diseases are mange, scurf, sore feet from foul quarters.
2) Cold sniffles (improper ventilation).
3) Stomach and bowel troubles (too much juicy green food).
b) There is a very objectionable odor if not kept clean.

THE TURTLE

A. Water Turtle

I. Feeding
a) Feed only once a week.
b) Food should be dropped into water because the turtle needs water to wash down food.
c) The turtle eats meal-worms, earth-worms, raw meat, bits of fish, turtle food, snails, insects.

II. Housing
a) An open box with a tub or pan of water inside.
1) Cover bottom of box with clean sand.
2) Arrange pan so that turtle can climb in and out easily.
3) The turtle likes to climb on rocks.
b) Aquarium with block of wood floating on water.
c) Place pen or tank so that there will be sunshine as well as shade.
d) Don't keep two turtles in same aquarium.
1) Will eat each other's tails and legs.
e) Never put turtles directly into cold water.
f) Change the water once a week, the day after feeding.
g) Do not allow turtle to fall. Cracked shell may cause death.

III. Habits
a) Most turtles hibernate in cold weather.
1) Provide sand or earth to dig in.
b) Travel about much so they need roomy pen or aquarium.
c) Breeding
1) Deposit eggs on land.
2) Dig hole in sand, deposit eggs, replace sand.
3) Eggs left to hatch by aid of sun's heat.
4) Eggs hatch in three or four months.
5) Young crawl out and creep down toward water.

IV. Temperament.
a) Become very tame but have little intelligence.

b) Recognize persons as source of food supply.
c) Some will hiss if disturbed.
d) Do not mind being handled by people they know.

B. Species of Water Turtles
  I. Terrapin
    a) Vivid border of red at edge of shell.
    b) Lays from five to eight eggs in June or July.
  II. Musk and Mud Turtle
    a) Musk Turtle emits strong odor when handled.
    b) Likes place to hide while feeding.
    c) Lays from three to seven eggs.
  III. Spotted Turtle
    a) Black shell ornamented with yellow spots.
    b) Lays from two to four eggs.
  IV. Snapping Turtle
    a) Undesirable pets. They will inflict serious wounds
  V. Soft Shell Turtle (fighter)
    a) Looks like animated pancake.
    b) Must have deep tank.
    c) Lays several dozen eggs.
    d) The young are gaily colored.

C. Species of Land Turtles
  I. Box Turtle (gentle)
    a) Lives entirely upon land but must have access to water.
    b) Keep this turtle where it can hunt worms, snails, and slugs.
    c) It may be fed berries or mushrooms.
    d) Lays from three to eight eggs.
  II. Wood Terrapin
    a) Plates of upper shell ornamented with concentric rings.
    b) All fleshy parts brick red except top of head and legs.
    c) Keep in pen with access to water.
    d) Gentle, interesting pets.
  III. Tortoise
    a) Webless feet which are large with clubby nails.
    b) Very tame, thrives in captivity.
    c) Must be kept in absolutely dry quarters.
      1) Temperature 70 to 80 degrees F.

WHITE RATS AND MICE

I. Feeding
  a) Small feedings.
    1) Dry bread crusts, grains, fresh vegetables and fruit, cheese, cod liver oil, nuts, egg yolks, insects, breakfast food.
  b) Keep fresh water in cage at all times.
  c) Green wood with bark on it, or empty cotton spool to gnaw on.
  d) Never feed meat (makes them vicious).
  e) Never feed sloppy food.
  f) Do not overfeed.
  g) Rodents must use their teeth.

II. Housing
  a) Small wire cages with net basket or compartments.

- b) Tin cracker box or wooden box covered with wire mesh.
- c) Branches, perches, swings for exercise.
- d) No paint or varnish.
- e) Cigar boxes are poisonous to them.
- f) Do not use exercise wheels because they might cut tails.
- g) Floor tray should be cleaned and scrubbed daily.
- h) Fill sleeping compartment with soft rags or cotton.
- i) Use sawdust, cork, excelsior, or newspaper as absorbent.
- j) For disinfecting purposes use:
  - 1) Clean sawdust sprinkled with disinfectant.
  - 2) Spray cage with disinfectant.
  - 3) Make disinfectant by diluting one teaspoonful of oil of Eucalyptus in one cup of water.

III. Habits
- a) Females should be placed in separate cage during pregnancy.
  - 1) They are irritable and males may eat the young.
- b) Gestation period is from twenty-one to twenty-five days.
- c) Do not handle babies or mother may destroy them.
- d) Males must be separated when four weeks old.
- e) Babies mature in four months.

IV. Temperament
- a) Mice are quite docile.
- b) Become very tame and are gentle and affectionate.

V. Classroom Comments
- a) Odor unpleasant.
- b) They may attract other mice.
- c) Carry disease.
- d) They are apt to bite.
  - 1) Wear gloves when handling them.

THE WOOD DUCK

I. Feeding
- a) For older and breeding ducks:
  - 1) Place in shallow feeding trough.
  - 2) Cut green foods in feed cutter.
  - 3) Feed grains moistened with water or milk.
  - 4) Plenty of green food: rye, clover, alfalfa, or corn.
- b) Ducklings from one to five days old need:
  - 1) Equal parts of corn meal and wheat bran mixed to crumbly mass with milk or water.
  - 2) Feed every two hours.
- c) Ducklings up to five weeks old need:
  - 1) Feed four times per day.
  - 2) Green foods as for older ducks.
  - 3) Wheat bran, corn meal, and ground oats, husks removed, moistened with water or milk.
  - 4) Add 5% grit to food.

II. Housing
- a) Cage of coarse wire netting at least four feet high.
- b) Roof or top of cage removable to allow cleaning.
- c) Place branches in cage for perching and encouraging nest building.
- d) Floor of cage.
  - 1) Dirt on floor six inches deep.
  - 2) Hole in one corner filled with gravel.

e) Cage is very difficult to keep clean.
   1) Keep it dry and clean.
   2) Change flooring very often.
   3) Have plenty of shade.

III. Habits
   a) Breeding.
      1) Drakes are selected during June, females in July.
      2) Lay eggs in morning, confine to pen until 9:30 A.M.
      3) Hatching season from Dec., through May and June.
      4) Incubation period usually 28 days.
      5) Ducklings usually require 24 to 48 hours to hatch after they pip the shell.
      6) Eggs should be sprinkled with warm water just before ducklings are ready to pip.

IV. Temperament
   a) Become very tame and have good disposition.
   b) Silent, pleasing whistling note.
   c) Intelligent and may be taught to come at call and feed from hand.

V. Classroom Comments
   a) Ducks are very hard to keep clean.
   b) They will have an odor if not kept clean.
   c) The Wood Duck is the only duck that can live without a pond nearby.

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*Manufacturers of Animal Cages**

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SCIENTIFIC DISCOVERIES AT CHANNEL ISLANDS NATIONAL MONUMENT

The Channel Islands National Monument, off the coast of California near the Mexican border, figures in the announcement of scientific discoveries made during 1938 by the National Park Service of the United States Department of the Interior. Pleistocene sediment was found on the mesa tops both of San Niguel and San Nicolas islands in the Channel Islands group.

To scientists this discovery means that a movement of the earth's crust has taken place since the ice age. The organisms in the deposit, their composition, their relation to rocks of known age, indicate that they were laid down in the sea during the Pleistocene Period—popularly known as the Ice Age. Since they now occur high above sea level, they point to a crustal movement of recent geological date.

REPORT ON THE EXAMINATION IN PHYSICS—ELEMENTARY OF THE COLLEGE ENTRANCE EXAMINATION BOARD, JUNE 22, 1938

ANDREW LONGACRE AND RUSSELL STURGIS BARTLETT
Phillips Exeter Academy

It may very well be true that familiarity breeds contempt. On the other hand, it is almost certainly true that a lack of familiarity breeds suspicion. Founded on a lack of familiarity with the aims, purposes, and procedures of the Examiners in Physics of the College Entrance Examination Board, there is growing in the minds of many teachers of Physics in secondary schools a feeling of uncertainty, a belief that the Examiners and the College Entrance Examination Board have established their own standards and methods without proper consultation with the most interested body, after the candidates themselves, the teachers in secondary schools who prepare the candidates for the examination. It is with the hope that a free exchange of ideas will reëstablish mutual confidence and understanding that we have undertaken a critical analysis of the latest examination in Physics.

Most striking is the appearance here for the first time of Part I, consisting of sixty questions, many of the multiple choice type, all requiring answers of great brevity. The idea seems to be excellent, that of touching lightly upon many topics, giving a sampling of a year's work in Physics. Perhaps this represents a first attempt to recognize and separate what might be considered as two primary objectives of the Physics examination, which are, of course, associated with two primary objectives of the high school course in Physics. These have been expressed in various ways. Perhaps for our purpose they may be described as (1) the acquisition of fundamental factual knowledge, and (2) the development of familiarity with the scientific method and a certain facility in accurate reasoning with scientific concepts. The series of sixty questions calling for brief answers seems to measure adequately the extent of factual knowledge acquired by the student, though it should not be assumed that this type of question requires no reasoning on the part of the studnet. The second part of the paper, consisting of eight questions calling for answers in essay form and involving some extended calculations, might be expected to offer scope for the display of powers of reasoning and familiarity with the

workings of the scientific method. Certainly we find in this part questions which require reasoning toward conclusions which probably have not been reached in the regular course, and applications of knowledge and method to new and interesting situations. Unfortunately, there seems to be also some factual material which is beyond the syllabus as most teachers of high school Physics conceive it. It is true that we have now no written syllabus, but we undoubtedly have precedent and custom, in accord with which we can determine the fitness or unfitness of a particular topic or question. 4d, 6c, and 7a, for example, are questions which most of us would place beyond the syllabus. Probably it is desirable that there should be questions beyond the ground covered by the average or mediocre student. Is there any provision for the fine student who has covered more ground but, unfortunately, has not dealt with the topics which the examiners have seen fit to include in this paper? It would seem fair to include in the examination only such material as is recognized to be an essential part of the course, or to go beyond that minimum in so many places and with such diversification that every student may be expected to find topics which give him scope to show his advanced knowledge, special understanding, and power of reasoning. Opportunities of this sort were granted in the past through the numerous optional questions. It is the feeling of the authors that the present paper offers no adequate substitute for that.

The College Entrance Examination Board has issued a statement of policy to the effect that the examination in Physics should attempt to differentiate between students in accordance with training, factual knowledge, and ability to reason, rather than to classify them according to their success in the performance of a number of discrete tasks. All can subscribe heartily to that policy. Judging from the last few examinations, with the reduction and elimination of optional questions, emphasis seems to be on the performance of a number of discrete tasks. In a sense, the examiners ask the students: "Can you do this? Can you do that?"; rather than, "What can you do?" Under this system we may find again that the students with the most enviable record on the examination are those whose teachers had best forecast the content of the examination. Furthermore, the student who is best prepared for a successful attack on the present examination is probably not best prepared for college work, either in Physics or in general. The student or the instructor, or

both, must make the unfortunate choice between these alternatives.

With the inevitable restriction of material, the present type of paper offers less of a challenge to the better student and fails to provide adequate opportunity for him to show his prowess. As the examination is restricted, so must be the course preparing for the examination. We all know the response of a class to a problem or line of reasoning which requires of the students a full exercise of their ability. Are future examinations and future classes to be without this stimulus? Questions of a comprehensive type not depending upon knowledge of a particular rule are all too rare, as are also those which involve an extension of reasoning from the material in the syllabus rather than an expansion of the syllabus itself. Yet it is through the answers to questions of these two types, if they are sufficiently varied, that the colleges are best able to select their most promising students.

Before considering the content of the paper in detail, two items regarding the format should be noted. First, the subjective questions were bound with the answer book, requiring a student writing a certain question to turn back and search for the answers to the question in order to verify some point of phraseology or data. This caused considerable unnecessary annoyance. Secondly, the objective questions calling for short answers and many rapid readjustments came first in the paper and almost certainly induced more fatigue than would the essay type questions had they come first.

As to the content of the examination, the distribution of the three hours was:

	Objective	*Subjective*	*Total*
Mechanics	33%	37.5%	36%
Heat	7	12.5	11
Electricity	27	25	26
Sound	10	0	3
Light	23	25	24

It is immediately apparent that Heat is given less time and Light far greater time than they occupy in the ordinary course. Furthermore, the overemphasis seems concentrated in Geometrical Optics.

Consideration of the sixty objective questions reveals some of considerable merit. Of these, Numbers 35, 42, 54 seem the best; while the fifteen questions, Numbers 4, 5, 22, 23, 26, 30, 32, 36, 38, 40, 41, 52, 53, 55, 58, all seem to be good questions. It is only natural that there should be at least a few that are

questionable. However, the proportion of these seems larger than need be, even for a first try at this type. Frankly, the authors do not know the answers to Numbers 18, 21, and 31; and Number 57 is inexcusable. Certainly Number 12, upon a detail of interference; 20, involving the erg; and 24, involving the dyne, are beyond the tacit syllabus. However, the authors, in accord with their stand regarding optional questions, feel that this is certainly not a disproportionate amount of extension. It is to be noted that nine questions concern geometrical optics and seven concern the direction of an electric current. Is this not a little heavy? Similarly, Numbers 11, 21, 27, 28, and 51 deal only with techniques; no principles whatsoever are involved. On the other hand, there are some glaring omissions; principally, Boyle's Law, Mechanical Equivalent of Heat, and Kinetic Theory.

Finally the authors want to commend the introduction of simple line drawings in Numbers 23, 30–51, and 58 of Part I. It is felt that Question 2 of the next part would have been improved had it been accompanied by a diagram. As it is, an important part of the answer depends upon the careful reading and understanding of a somewhat detailed and complicated description. A drawing would have made Question 2 a test of physical principles rather than reading.

In regard to the subjective questions, we should like to examine them individually after the manner of our English brethren in the Science Masters' Association.

1. Water is pumped into an airtight tank 32 feet high and 5 square feet in cross section, through a pipe entering the bottom of the tank, until the air previously filling the tank at an absolute pressure of 15 pounds per square inch is under an absolute pressure of 60 pounds per square inch.
   a) What volume of water does the tank now contain?
   b) What is the pressure now on the bottom of the tank?
   c) If 80 cubic feet of water is drawn off, what will the air pressure be in the tank?

This question deals with a stereotype subject in an original manner and combines two ideas in a way to offer a real test of a student's understanding. Part c adds no new physical principle and could well have been omitted.

2. A springboard projecting horizontally over a swimming pool is in the form of a uniform plank 15 feet long and weighing 120 pounds. It is fastened down at one end and rests upon a crosspiece placed 5 feet from this end.
   a) Draw a diagram and find the forces (amount and direction) holding the board when no one is on it.
   b) If a man stands on this board directly over the crosspiece, will the force on the latter be greater than, equal to, or less than the

force on the crosspiece when the man stands on the free end of the board? Give reasons for your answer.

Part a is routine. Part b calls for quantitative thinking and information without numerical data. Experience seems to show that this type of question affords a more searching test than a numerical problem.

3. On a level road a car, A, is in the act of passing a similar car, B, similarly loaded. At the instant when A and B are side by side, A's speed is twice B's and each driver applies the brakes with equal force until his car has stopped.
   a) Compare A's stopping time with B's. Give reasons.
   b) Compare A's stopping distance with B's. Give reasons.
   c) Compare A's loss of kinetic energy with B's. Give reasons.
   d) What became of the lost kinetic energy?

Like 2b, this question is good, though the last part is a weak climax.

4. Give a brief explanation for the following facts:
   a) On a hot day, a person feels cooler when the relative humidity is low than when it is high.
   b) On a calm evening following a hot day, mist forms over a pond or stream.
   c) When placed in a thermos bottle, hot tea remains hot while iced tea remains cold.
   d) A good watch keeps accurate time in spite of a wide variation in temperature.

The first three parts of this are routine, while the fourth part is a specialized application which may or may not have been encountered. If it has not been encountered, no depth of physical insight can produce a correct answer.

5. a) If an electric light bulb consumes 30 watts when operating normally under a potential difference of 120 volts, what is its resistance?
   b) The same bulb is then connected to a dry cell furnishing 1.2 volts, and a current of only 0.02 ampere passes through it. What is its resistance now?
   c) If the resistance of the tungsten filament in the light is proportional to its absolute temperature, what is the temperature of the filament under normal operation, if its temperature when used with the dry cell is taken to be 27°C?

The first two parts are routine, and there is considerable duplication. If Part c tests the ability of the student to apply knowledge to new conditions, it is excellent. Since, however, the exact law governing the case is stated in full, one might suppose that the question would involve nothing more than the knowledge of the absolute temperature scale.

6. a) Describe, by the aid of a labeled diagram, the construction of a simple voltaic cell.
   b) When the terminals of such a cell are connected by a wire, state what effects may be observed within the cell.

c) In what respects does the modern dry cell differ from the simple voltaic cell? What advantages are gained by these modifications?

Parts a and b together seem to offer a fair test of fundamental understanding. Part c definitely goes beyond the syllabus and depends upon purely technical knowledge.

7. a) What is the physical cause of the refraction of light?
   b) Show by a labeled diagram why the bottom of a clear-water pond appears closer to the surface than it really is.
   c) The page of a book held at normal reading distance is examined first through a converging lens (reading glass) and then through a diverging lens.
      (1) State the character of the image formed in each case.
      (2) Which image is farther from the eye? Give reasons for your answer.

Part a is certainly beyond the syllabus. Furthermore, an adequate answer is not possible under present-day knowledge of Physics. A particular answer accepted by convention is called for. The point should also be made that any explanation of refraction is unsupported by direct evidence within the experience of the student. With the very limited study of the wave theory of light, we can see no justification for introducing it as an explanation of refraction when the explanation is entirely inadequate.

8. a) A 135-candle-power lamp is placed at one end of a meter stick (at the zero mark), and a lamp, L, of unknown candle power at the other end (at the 100 cm. mark). If a screen placed at the 75 cm. mark is illuminated equally on both sides, what is the candle power of the lamp, L?
   b) A tree stands on the margin of a pool which is 21 feet wide. On the the ground 3 feet back of the opposite margin of the pool stands a man whose eye is 5 feet above the level of the pool. He can see the image of the tree top just touching his margin of the pool.
      (1) Show by a diagram the position of the image of the tree.
      (2) How high is the tree?

Part a is routine, while Part b is badly written. Certainly the image is *not* "just touching his margin of the pool."

FUR FARMING*

L. N. SILVERMAN
American Steel and Wire Company, Chicago, Illinois

The breeding of silver foxes in captivity was the beginning of fur farming on a commercial basis and this was about fifty-nine years ago in Prince Edward Island, Canada. Charles Dalton, later made Sir Charles in consideration of his establishing such a profitable industry, started with a pair of silver foxes caught in the wilds. He was very fortunate in that the animals lived and bred. It is reported that after a few years he sold his breeding stock for a million dollars.

The silver fox is a sport or a freak from a red fox. Naturally they were very scarce and when one was found it was presented to the King and worn only on state occasions. At that time only Royalty was permitted to wear silver fox. I will devote more time to silver foxes than other fur bearers, for they rank first in the amount invested and amount of income.

There is today about $70,000,000 invested in fur farming and the annual income is more than $10,000,000. The industry employs thousands of workers and is an important market for grains, meat, fish, milk and practically all kinds of vegetables. It is also an outlet for old horses that formerly were often worked until they dropped, or were turned loose. Today horses are bought in the fall when farmers are through working them and do not care to feed them through the winter. Some are very sentimental about horses they have had for a long time and wait around until they are killed, but not watching the killing.

The fur of a silver fox cannot be imitated, for each hair has three distinct colors: drab at the base, then a white band of about three-fourths of an inch and it is tipped with black. Silver foxes are classified as black, one-quarter silver, one-half silver, three-quarters silver, full silver and extra full silver. The last two color phases are the highest priced, probably because they are not plentiful and are the most extensively advertised. They are not as beautiful as the three-fourth silvers for the full silvers lose the black band and many have a white appearance. With each successive breeding of such foxes the fur gets shorter. The three-fourth silvers generally have a black line down the center

* Read before the Biology Section of the Central Association of Science and Mathematics Teachers, Nov. 25, 1938. Mr. Silverman is President of the Illinois Silver Fox & Fur Breeders Assn., Inc., and Director of Fur Farm Fencing, American Steel & Wire Company.

of the back, the fur is longer and the black band gives a beautiful veiling.

A silver fox looks large, but really has a small body, it is mostly fur. The Eastern Standard breed, which originated on Prince Edward Island, weighs from 10 to 12 pounds, while the Alaskan breed is heavier. Some have bred the Eastern Standard with the Alaskan foxes and have produced a cross fox, but both this fox and the Alaskans, while being larger than the Eastern Standard, have coarser fur. The foxes raised in this climate have very silky fur but farther north the fur is coarser.

The animals are mated in pairs, although some have tried polygamous breeding with fair success. Each pair is kept in a wire pen varying in size, but 25 feet by 50 feet and 7 feet high seems the most suitable. Some imbed the side wires in the ground while others cover the entire bottoms of the pens with netting. A 24-inch overhanging prevents the animals from getting out over the top. They are great climbers.

The animals mate in January and February. The gestation period is 51 days. The pups do not open their eyes for 18 days. Litters range from one to eight, but three is a good average. The animals are attacked by round worms, hook worms and lung worms, occasionally by tape worms. The lung worms are the most difficult to control; no medicine will touch them. Foxes with lung worms are kept off the ground on wire netting having meshes sufficiently large so the droppings will go through. After a few weeks the worms will leave the animals to such an extent that they will grow pretty good fur. They are generally pelted, for after having an attack of lung worms they may not breed and if they do breed, the pups usually have the worms.

The two diseases that cause a heavy loss of animals are encephalitis and distemper. My foxes had both in two successive years. I got them under control with only small losses, but after an attack most of the animals must be pelted and the fur is poor. It takes years to bring back the standard of fur quality that was formerly on the ranch.

The Bureau of Biological Survey of the Department of Agriculture in Washington has an experimental fur farm and carries on research work of great benefit to breeders of foxes and minks. The Universities at Wisconsin, Minnesota, Michigan and Iowa are very aggressive in helping fur farmers, while little or nothing has been done at the University of Illinois so far as I can learn.

The animals grow quickly and in eight months are ready for pelting. The young breed in one year. They are killed with a hypodermic needle or by gas, then are skinned, the pelt is turned inside out and the fat removed by scraping. Care must be taken not to scrape so close as to bare the roots of the hair, which would result in the fur shedding the same as if the animal had been killed too early, before it was prime. Next the pelt is slipped over a drying board, with the fur inside and edges tacked down. When sufficiently dry and before the skin hardens, the pelt is removed from the board, turned so the fur is out and replaced for further drying. They are next drummed to remove dirt and grease from the fur and shipped to auction houses to be sold.

Foxes are raised in many other countries and United States' breeders have great competition from Denmark, Norway, Sweden and Canada.

Most women want silver foxes either in the shape of scarfs, capes or coats and this may have been brought about largely by the free advertising obtained through the moving pictures. Then the fact that prices originally were so high may have something to do with the demand. The colorings in silver fox bring out all the beauty in a woman's face instead of detracting from it as do many other furs.

The raising of minks is growing very rapidly, perhaps too much so for the good of the breeders. Prices now are about twice as much as are obtained for wild minks because the skins can be taken when they are prime and they have much better color. Ranch bred minks recently sold at $22.00 to $27.50 according to the size and grade.

The breeding of karakul sheep for fur is advancing rapidly in this country. They are killed shortly after birth while the curl is short and tight. Some are taken prematurely and that fur is known as broadtail.

Chinchilla seems to be the highest priced fur. A New York dealer recently advertised he had procured 135 South American chinchilla skins which he would gladly make into a wrap at a cost of $35,000. Another furrier advertised a Russian sable cape for $25,000.

Some have attempted to raise muskrats in captivity, but there is little if any of it being done now. It was impossible to raise them and compete with the price of rats caught in the wilds.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitte in the best form will be used.

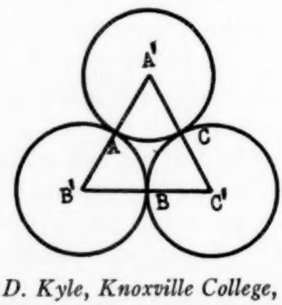
LATE SOLUTIONS

1579. *James G. Go, Cebu, Cebu, P. I.*

1582. *W. R. Smith, Lewis Institute, Chicago, Ill.*

1586. *Proposed by Claude M. Shepley, Minneapolis.*

Three circles each of radius r are tangent to each other externally at Points A, B, C. If the area of the portion bounded by the arcs AB, AC, and BC is one-half acre, find the radius.



Solution by Garland D. Kyle, Knoxville College, Knoxville, Tennessee

Let A', B', and C' be the centers of the circles so arranged. Obviously the sides of the triangle of centers are each $2r$ and the area of this equilateral triangle is $r^2\sqrt{3}$ square rods. The area of the bounded portion is given to be one-half acre or 80 square rods. Since the three sections are equal, the area within the triangle and outside the bounded portion is

clearly $\frac{\pi r^2}{2}$. Therefore the following equation results:

$$r^2\sqrt{3}-80=\frac{\pi r^2}{2},$$

whence

$$r=\frac{4\sqrt{10}}{\sqrt{2\sqrt{3}-\pi}}=22.34 \text{ rods (approximately).}$$
$$=367 \text{ ft } 6 \text{ in.}$$

Solutions were also offered by Lewis D. Rice, East Sparta, Ohio, W. R. Smith, Lewis Institute, Chicago, S. E. Field, Gogebic Junior College, Ironwood, Mich., O. L. Dunn, Vincennes, Indiana, Charles W. Trigg, Los Angeles, W. R. Warne, Minneapolis, Minn., Vernon D. Taggart, Worley, Idaho, R. R. Creighton, Audubon, N. J., A. MacNeish, Chicago, Ill., Arthur Danzl, Collegeville, Minn., John F. Wagner, Lewis Institute, Chicago, Ill., and Edward C. Varnum, Clyde, Ohio.

1587. *Proposed by Lester Dawson, College, Alaska.*

A circular cylindrical can which stands vertically is used to measure the amount of rainfall when rain is falling at angle of 60° with the horizontal. What is the true rainfall if two inches were reported?

Solution by O. L. Dunn, Vincennes, Indiana

The true rainfall is the depth over a section at right angle to the direction of fall. In this case the right section is an eclipse with semi-major axis equal to r and semi-minor axis equal to $r\cdot\cos 30°$, where r is the radius of the cylinder.

The area of the section is then $\pi r^2\cdot\cos 30.°$

If t is the correct rainfall we have,

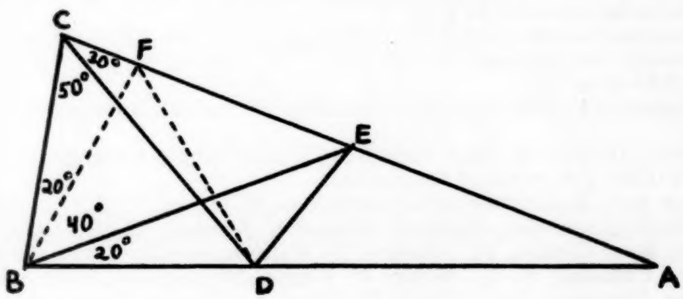
$$t\pi r^2 \cos 30° = 2\pi r \quad \text{from which}$$

$$t=2\sec 30°=\frac{4\sqrt{3}}{3}=2.3.$$

Solutions were also offered by Garland D. Kyle, Knoxville College, Knoxville, Tenn., John F. Wagner, Lewis Institute, Chicago, Ill., and also by the proposer.

1588. *Proposed by Cecil B. Read, Wichita, Kansas.*

In a triangle ABC, angles B and C are each eighty degrees. CD is drawn, intersecting AB at D, such that angle $BCD=50°$; BE intersects AC at E,



making angle $CBE=60°$. Find, by methods of plane geometry alone, angle DEB.

Solution by Aaron Buchman, Buffalo, N. Y.

Draw BF, interesecting AC at F, such that angle $CBF=20°$.
Draw FD. Then $CB=FB$, also $CB=BD$, Hence $FB=BD$.
$\therefore$ triangle FBD is equilateral. Hence $FB=FD$ and $FB=EF$.
$\therefore$ $FD=EF$ and $\angle DEF=\frac{1}{2}(\angle DFB+\angle BFC)=\frac{1}{2}(60°+80°)=70°$.
But $\angle BEC=40°$. $\therefore$ $\angle DEB=30°$.

A solution was also offered by M. Kirk, West Chester, Pa. and Marion Lund, Minneapolis.

1589. *Proposed by O. F. McCrary, Raleigh, N. C.*

A man has three sons, ages 7, 14, and 21. He has \$1,500 he wishes to divide among them. The 21-year-old is given his part of the money. The 14-year-old son's part is put in the bank to draw interest at 6% compounded annually until he is 21 years of age. The 7-year-old son's part is also deposited in the bank at 6% compounded annually until he is 21. When each one has received his money they will each have the same amount. How is the \$1,500 divided?

Solution by S. E. Field, Gogebic Junior College, Ironwood, Michigan

Let x = amount deposited for 7-year-old son.
$y=(1.06)^7x$ = amount deposited for 14-year-old son.
$1500-(x+y)$ = amount received by 21-year-old son.
Then $(1.06)^{14}x=1500-[1+(1.06)^7]x$.
From this equation we obtain

$$x=\$314.83$$
$$y=\$473.38$$
$$1500-(x+y)=\$711.79$$

Solutions were also offered by Lewis D. Rice, East Sparta, Ohio, Charles W. Trigg, Los Angeles, O. L. Dunn, Vincennes, Ind., M. Kirk, West Chester, Pa., William Linter, Gideon, Mo., Garland D. Kyle, Knoxville, Tenn., John F. Wagner, Lewis Institute, Chicago, Ill. and Edward C. Varnum, Clyde, Ohio.

1590. *Proposed by William W. Taylor, Port Arthur, Texas.*

Construct a triangle, given the circumradius, the base, and the ratio of the altitudes to the other sides. See figure on following page.

Solution by Aaron Buchman, Buffalo, N. Y.

Let the circumradius be r, the base be c, and the ratio of the altitudes to the other two sides be $g:m$.

Construct a circle with radius r and construct chord $AB=c$. Divide AB internally and externally in the ratio $g:m$, that is, so that $AD:DB=AE:BE=g:m$

Construct a circle upon DE as diameter. Let the two circles intersect at C.

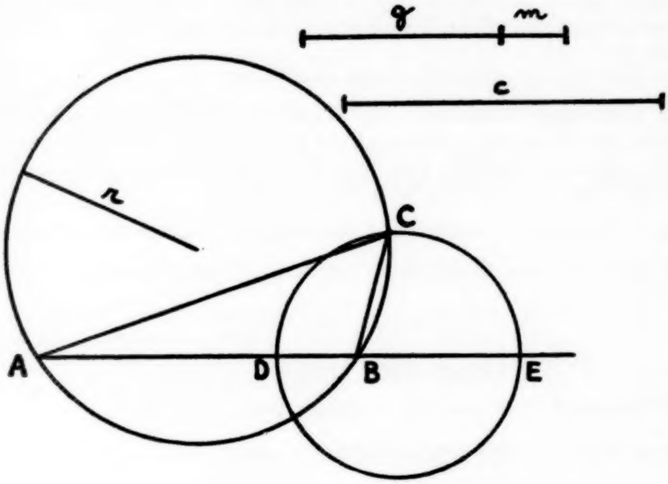
Draw AC and CB. Then triangle ACB is the required triangle.

$AC:CB=g:m$ (circle of Apollonius).

But $AC:CB$ = altitude to CB: altitude to $AC=g:m$.

Solutions wee also offered by Edward C. Varnum, Clyde, Ohio, M. Kirk, West Chester, Pa., Garland D. Kyle, Knoxville, Tenn., John P. Hoyt, Cornwall, N. Y., Walter R. Warne, Minneapolis, Minn., O. L. Dunn, Vincennes, Ind., Charles W. Trigg, Los Angeles, Boris Garfinkel,

Buffalo, N. Y., W. R. Smith, Lewis Institute, Chicago, Mozelle Simpson, Norman, Oklahoma, and also by the proposer.



1591. *Proposed by Walter R. Warne, Minneapolis, Minn.*

Solve the system

$$x^3+y(xy-1)=0$$
$$y^3-x(xy+1)=0.$$

Solution by Malcolm Kirk, West Chester, Pa.

$$x^3+y(xy-1)=0 \tag{1}$$
$$y^3-x(xy+1)=0 \tag{2}$$

$x=y=0$ satisfies the system.

From (1) $$\frac{x^3}{y}=1-xy. \tag{3}$$

From (2) $$\frac{y^3}{x}=1+xy. \tag{4}$$

Multiply (3) by (4) $$x^2y^2=1-x^2y^2 \text{ from which } xy=\frac{\sqrt{2}}{2}. \tag{5}$$

Substituting in (1) $$x^2=\tfrac{1}{2}(\sqrt{2}-1) \tag{6}$$

Hence $$x=\pm\sqrt[4]{\frac{\sqrt{2}-1}{2}} \tag{7}$$

and from (5) $$y=\pm\sqrt[4]{\frac{\sqrt{2}+1}{2}} \tag{8}$$

Solutions were also offered by Garland D. Kyle, Knoxville, Tenn., John F. Wagner, Lewis Institute, Chicago, Aaron Buchman, Buffalo, N. Y., Levi Ritter, St. Paul, Minn., and also by the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1582. *Don Inhoff, Lewis and Clark High School, Spokane, Washington.*

Note: Miss Kate Bell, teacher of Mr. Imhoff, sends word that this solution was done by Calculus, and that the solver worked out the Calculus in his spare time with no help from any one. Rah!

1586, 7. *Don Imhoff, Lewis and Clark High School, Spokane, Washington.*

1580. *Ernest Greene, Lewis and Clark High School, Spokane, Washington.*

PROBLEMS FOR SOLUTION

1604. *Proposed by Howard D. Grossman, New York City.*

Show that $\sqrt[1]{i}=23\frac{1}{7}$ (approximately), where $i=\sqrt{-1}$.

1605. *Proposed by Hugo Brandt, Chicago.*

For the curve $3 \text{ arc tan } y.x = \text{arc tan } \frac{y}{x-2}$, find

(a) the maximum y and the corresponding x.
(b) the asymptote.

1606. *Proposed by Marvin Hirsch, Lewis Institute, Chicago.*

Write the fraction $\frac{1}{x^{5/6}+0}$ with a rational denominator.

1607. *Proposed by Norman Anning, University of Michigan.*

Exhibit x^6+27y^6 as the product of its quadratic factors and show that, when k is any odd integer greater than one, $27^\circ+1$ has three factors of the same order of magnitude.

1608. *Proposed by Lawrence R. Schoenhals, Huntington, Ind.*

From any point p within an equilateral triangle, draw perpendiculars to the medians. The triangle formed by joining the feet of these perpendiculars is equilateral.

1609. *Proposed by C. W. Trigg, Los Angeles City College.*

Show that there are only two five-digit integers, each with three like initial digits and each of whose squares is composed of distinct digits.

SCIENCE TEACHERS

What use do you make of **Science Questions?** Many pupils are learning to do real study by using this department. Show the next three pages of this issue to your classes and listen to the discussion.

SCIENCE QUESTIONS

April, 1939

Conducted by Franklin T. Jones

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Send in your "Do You Know the Answer?" Questions.

Please send copies of tests and examinations to Franklin T. Jones, 10109 Wilbur Avenue, S.E., Cleveland, Ohio.

GQRA—NEW MEMBERS

264. Hollis D. Hatch, English High School, Boston, Mass.
265. Bernette Schwarz, Sparta High School, Sparta, Wis.
266. C. O. Pauley, Valparaiso High School, Valparaiso, Ind.
267. Carter Frank, Riverside High School, Buffalo, N. Y.

WHAT IS WRONG?

853. *Proposed by John M. Michener (GQRA No. 117), Wichita High School East, Wichita, Kansas.*

Here is a problem suggested by an illustration in an advertisement advertising the new physics test *Physics of Today* published by Houghton Mifflin. The illustration shows the bursting of a barrel by hydrostatic pressure caused by a column of water about 10 feet high. What would be wrong with such an illustration?

854. *Proposed by Bernette Schwarz, Sparta High School, Sparta, Wis. (Elected to the GQRA, No. 265).*

How would you explain to a ninth grade science student why one gram of steam at 212°F. (one atmosphere pressure) gives out less heat when condensing than the same weight of steam at 180°F.?

PATH OF A BULLET

855. *Proposed by Carter Frank (Elected to the GQRA, No. 267), student at Riverside High School, Buffalo, N. Y.*

Will a bullet fired from a gun barrel that is perfectly level rise above the muzzle of the gun as it appears to do in pictures of bullet flight trajectories?

TRY THIS EXPERIMENT

856. *Proposed by Louis T. Masson (GQRA No. 252) author of "Physics Made Easy," Riverside High School, Buffalo, N. Y.*

Take a medium weight rubber band; Hold the ends loosely between thumb and finger (both hands). Let a pupil feel the temperature of the middle of the band. Give the band a good pull (stretch between hands). Release the tension and let the pupil again feel the temperature.

Is it hotter or colder? Why? (Try it again and again until you are sure. Report results to the EDITOR.)

A BIOLOGIC EXPERIMENT AND ITS ANSWERS

857. *Proposed and answered by Philips B. Sharpe, (Elected to the GQRA No. 262), Science Supervisor in the Public School of Greenwich, N. Y.*

"May I join the GQRA by answering a question of which I am the author in its original form, but which appeared on the Regents Examinaton for General and Advanced Biology in June 1937, Part II, No. 5."

No. 5. A boy devised an experiment to test the old belief that an iron plow poisons the soil. He recorded his experiment as follows:

Procedure: I planted some beans in a rusty tomato can that did not leak, placed it on a window sill and watered it every day.

Observations: None of the beans came up.

Conclusion: Iron poisons the soil.

a. Give *three* reasons why this experiment fails to prove that iron poisons the soil.

b. Explain the importance of the *control* (check) in a biologic experiment.

Answer:

(*a*) 1. It might be that his seeds were useless.
2. It might be that he planted the seed too deep.
3. It might be that he drowned the seed.

(*b*) The above list of possible interpretations of this experiment shows clearly why a control is necessary in a biologic experiment,—to eliminate all explanations but one, which may be adopted as the conclusion.

A suitable control for this experiment would be to divide the seeds and plant half of them in say, a glass can. The two set-ups would be identical in every respect but one, the material of the can. They would be treated identically, too. Then, if no seeds came up in either of the cans he would know that he had to start all over and be more careful. If seeds came up in the glass can but not in the iron one, there would be only one possible conclusion to hold until the experiment could be repeated. He would then have proved that under the conditions just described, iron in the soil discourages the sprouting of beans. A control experiment limits the number of variables.

DO YOU KNOW THE ANSWERS?

36. What makes an electric clock run slow?
37. How many seeds of "red clover" in a pound?
38. What is the chemical name of the bristles in Dr. West's tooth-brushes?
39. Can a snake back up?

(*Proposed by John C. Packard, GQRA No. 1*)

40. When Joan plays the radio loudly, the china cabinet "rattles." Why?

(*Modified from "Physics Made Easy" by Louis T. Masson, GQRA, No. 52*)

Propose short, snappy questions for "Do You Know the Answers?"

ANSWERS TO 26-30

26. *Scientific Completion*—"Prediction: Prosperity will be rising in America when the sap is rising in the trees." (After *Forbes'*)
27. *All time record for weight-lifting*—
    P. J. McCarthy at St. Louis in 1898, 6370 lbs.
28. *Chemical kindling*
    "Stubs of candles," says W. R. Smith, GQRA No. 176.
29. *Meniscus of water*—U is up.
    Meniscus of Mercury—U is down.
30. *Liquid air*—How cold?
    B.P. oxygen is −183°C.; B.P. nitrogen is −195°C.

BURSTING THE CASK

851. *Proposed by John C. Packard (GQRA No. 1), Brookline High School, Brookline, Mass.*

Pascal's experiment of the "bursting of a cask" by hydrostatic pressure is often illustrated by the picture of a man climbing a ladder and pouring water into a long tube inserted in the head of the cask.

Query—How high must the man climb if the hydrostatic pressure of the column of water is to burst the cask? Would the cask give away at the staves or at the head next the ground? Has anyone tried it?

Answer by C. O. Pauley (Elected to the GQRA. No. 266), Head of Science Dept., Valparaiso H.S., Valparaiso, Ind.

Several years ago, while teaching physics at Linden, Indiana, the question of bursting the cask by hydrostatic pressure aroused enough interest to actually try the experiment.

A wine cask was filled with water and placed on the ground below a second story window of the school building. A piece of water pipe about 20 feet long was inserted in the top of the cask, and extended upward to the window above. Enough water was poured into this 20 ft. pipe to fill it. When the water reached a height of about 15 ft. above the head of the cask, the hoops and seams in the cask expanded enough to allow the water to slowly leak out. There was no bursting of the cask as is often shown in pictures, but the expansion of seams and hoops demonstrated the effect of the water pressure.

If the "water head" in the pipe was 15 ft. above the level in the cask, then 15×62.4 equals 936 lbs. pressure per *square foot* on the head of the cask. 936 divided by 144 equals 6.5 lbs. pressure per *square inch.*

SINGING TELEGRAPH WIRES

22—*of "Do you Know the Answers?"*

Answer by Hollis D. Hatch (Elected to the GQRA, No. 264) English High School, Boston, Mass.

22. Why do telegraph wires "sing" in a winter wind?

One thing this singing does *not* do is exemplify the laws of vibrating strings. Strouhal in 1878 found that the frequency of sound produced when a wind passes a cylinder was proportional to the relative velocity and inversely proportional to the diameter of the cylinder. Note that the length of the cylinder (wire) does not affect the pitch while the pitch of a vibrating string varies inversely as the length.

Experiments by the National Physics Laboratories found that behind

such a cylinder, a vortex of air was formed which moved rapidly from side to side behind the wire. The oscillation of this vortex may produce an audible sound according to the empirical formula $n = \frac{.185\ V}{D}$. Photographs of the vortices and a discussion of the above may be found in *Applied Aerodynamics* by Bairstow.

As a mode of recognizing contributors, the Guild of Question Raisers and Answerers (GQRA) has been formed and 267 contributors have already been admitted to Membership. Classes or individuals, may become members by proposing a question or submitting an answer.

JOIN THE GQRA

BOOKS AND PAMPHLETS RECEIVED

Physico Chemical Experiments, by Robert Livingston, Associate Professor of Physical Chemistry, University of Minnesota, Minneapolis, Minn. Cloth. Pages xi+257. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.25.

Business Mathematics, by Isaiah Leslie Miller, Late Professor of Mathematics, South Dakota State College of Agriculture and Mechanic Arts, and Clarence H. Richardson, Professor of Mathematics, Bucknell University. Second Edition. Cloth. Pages xii+352. 14.5×23 cm. 1939. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $3.75.

A Course in General Mathematics, by Clinton Harvey Currier, Associate Professor of Mathematics, Brown University; Emery Ernest Watson, Professor of Mathematics, Iowa State Teachers College; and James Sutherland Frame, Assistant Professor of Mathematics, Brown University. Revised Edition. Cloth. Pages ix+382. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

Introductory College Physics, by Oswald Blackwood, Professor of Physics, The University of Pittsburgh. Cloth. Pages xiv+487. 14.5×23 cm. 1939. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.50.

Analytic Geometry, by Roscoe Woods, Associate Professor of Mathematics, University of Iowa. Cloth. Pages xiii+294. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.25.

Educational Activities of the Works Progress Administration, by Doak S. Campbell, Frederick H. Blair, and Oswald L. Harvey, prepared for the Advisory Committee on Education. Staff Number 14. Paper. Pages xiv+185. 14.5×23.5 cm. 1939. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price 25 cents.

The Fetal Pig, An Introduction to Mammalian Anatomy, by Hazel E. Field, Associate Professor of Biology at Occidental College. Paper. Pages ix+53. 14×21.5 cm. 1939. Stanford University Press, Stanford University, Calif. Price 75 cents.

Our Taxes—and What They Buy, by Maxwell S. Stewart. 32 pages. 13.5×21.5 cm. 1939. Silver Burdett Company, 45 East 17th Street, New York, N. Y. Price 10 cents.

Anderson's Herbarium "Cellophane" Protected Mountings for Specimens, by E. S. Anderson, Chelsea High School, Chelsea, Massachusetts. The

camp special, 25 cents each. Loose-leaf forms: 7″×9″ Herbarium, 20 pages, 35 cents each, 9″×12″ Herbarium, 25 pages, 50 cents. E. S. Anderson, Box 265, Astor Station, Boston, Mass.

The Synthesis of Science and Religion, by Frederick Kettner. Biosophical Series, Number IV. 22 pages. 15×22.5 cm. 1939. The Biosophical Institute, 23 West 87th Street, New York, N. Y. Price 10 cents.

Safety Education in Industrial School Shops, by Lester K. Ade, Superintendent of Public Instruction. Bulletin 332. 87 pages. 15×23 cm. 1938. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

Interpretations and Regulations for the Administration of the Barber Law, by Lester K. Ade, Superintendent of Public Instruction. Bulletin 604. 27 pages. 15–23 cm. 1938. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

Erratum: In the February issue the book review of *Experience Units in Biology* by Faust and Biecher was erroneously listed as *Experimental Units in Biology*. Also the number of units was given as 19 instead of 20.

BOOK REVIEWS

A Course of Study in Chemical Principles, by Arthur A. Noyes, Late Professor of Chemistry, California Institute of Technology and Miles S. Sherrill, Professor of Physical Chemistry, Massachusetts Institute of Technology. Second edition, rewritten. Cloth. Pages xxv+554. 15×22 cm. 1938. The Macmillan Company. New York. Price $5.00.

Quoting from the preface to the second edition. "The first and second laws of thermodynamics are now presented and thoroughly discussed at the beginning of the book instead of at the end. By this rearrangement, thermochemistry is fundamentally treated at an early stage through application of the first law. Furthermore, the foundation is laid at the beginning of the subsequent thermodynamic treatment of the laws of chemical and physico-chemical equilibrium. In this treatment, progressively pursued throughout the book, the repeated application of the second law results for the student in an increasingly better comprehension of its basic concepts. The system of thermodynamics thus developed is made rigid by the adoption of the activity concept of G. N. Lewis. In the final chapter the third law of thermodynamics thus developed is made rigid by the adoption of the activity concept of G. N. Lewis. In the final chapter the third law of thermodynamics is presented and applied. Also the equilibrium of gaseous reactions in relation to spectroscopic and heat data is briefly considered." "The kinetic theory is here more fully developed than in the first edition. The essential features of the Debye—Hückel ion attraction theory are presented."

The format remains the same as in the previous edition.

DRULEY PARKER

Chemistry and You, by B. S. Hopkins, Professor of Inorganic Chemistry, The University of Illinois; R. E. Davis, Head of the Chemistry Department, Lane Technical High School, Chicago; H. R. Smith, Head of the Chemistry Department, Lake View High School, Chicago; Martin V. McGill, Head of the Chemistry Department, Lorain High School, Lorain, Ohio; G. M. Bradbury, Head of the Science Department, Montclair High School, Montclair, New Jersey. Cloth. Pages ix+802. 15×21 cm. 1939. Lyons and Carnahan, Chicago.

"During the last few years the high school science curriculum has been given a critical examination. As a result of this examination, new aims have been developed; new methods and a changed emphasis have been used to make these aims become realities in the lives of our students." The material of this book is presented in sixteen units with each unit divided into several problems. The authors recommend that the first nine units be included in every course and that a choice be made from the last seven units to finish out the work of a year. Each unit is introduced by a page of preview and a statement of the problems to be studied. At the end of the discussion of each problem there are references entitled "Readings for Pleasure and Profit." These references are to books of a popular nature which should be in every high school science library. Also, at the end of each problem there are sections devoted to "Applying in Life What You Have Learned in Chemistry," "Putting Chemistry to Work" and "Research Activities That You Will Enjoy." To the reviewer this is the most interesting portion of the book.

The illustrations are of excellent quality and well labeled. The binding is very sturdy and of an attractive color. From the standpoint of atomic theory and industrial processes the book is very much up-to-date. A very complete appendix and glossary are another attractive features. Indexed. The authors are to be congratulated on this text. It is one of the best written, most carefully planned and most interesting high school chemistry texts that has come to the reviewer's attention in recent years. The only possible criticism that we could make is that the book is rather appalling in size. Every chemistry teacher should examine and consider this most recent text.

DRULEY PARKER

Health and Achievement. A Textbook of Health with a Physiological Background, by Edgar A. Cockefair, Professor of Biology, Central Missouri State Teachers College and Ada Milarn Cockefair, Instructor in Physiology, West High School, Madison, Wis. Cloth. Pages ix+536. 20×11.5 cm. 317 figures. 1936. Ginn and Company, New York, N. Y.

This book should be of interest to the high school student because: it is very readable, written in as narrative a form as possible, has significantly titled paragraphs, uses simple terms where usually technical ones are employed. The book shows the youth not only the desirability of having good health but the fundamental aspects of keeping good health. Youth is generally fairly healthy and so might only take an academic interest in a discussion of it such as this, but the reviewer feels that the high school student after using this volume would come away with the proper understanding of the relation between laws of human health and the physiological basis underlying such health. The text covers nine units titled as follows: I—The Problem of Nature and Value of Life. II—The Problem of Improvement in Life. III—Where Life gets its Energy, IV—How the Body Cares for its Needs. V—The Body in Action. VI—The Control of the Body. VII—Special Senses and The Acquisition of Knowledge. VIII—Ill Health and its Causes. IX—Life and its Purposes.

A study guide, a self test and suggested observation studies follow each chapter of which there are twenty-eight. The book is well indexed, has a glossary and a good reading list by chapters.

A. G. ZANDER

Methods and Materials for Teaching Biological Sciences. A Text and Source Book for Teachers in Training and in Service. By David F. Miller, Associate Professor of Zoology and Supervisor of Teacher Training in the

Biological Sciences, Ohio State University and Glenn W. Blaydes, Associate Professor of Botany, Ohio State University. Cloth. Pages xii +435. 23×15.5 cm. McGraw-Hill Book Co. New York and London. 1938. 109 pages with figures. Price $3.00.

This book should fill a long felt want in the field of biology teaching especially for the young teacher who has not as yet acquired a teaching background, in this particular field. The book has the psychological range from the junior high school to the junior college level. This volume should show the teacher how not to rely too much on a textbook; it guides him in the selection and the procuring of pertinent and interesting teaching aids and how they may be effectively used. This book handles the problem and project aspect of teaching biology in a very original way. The book is divided into two parts viz:

I—Principles and Classroom Methods. The chapter headings are suggestive. Here they are: 1—The Biological Basis of Education. 2—The Objectives of Teaching in Biological Subjects. 3—Types of Courses. 4—Methods of Presentation. 5—Making a Teaching Plan. 6—An Evaluation Program. 7—The Lack of Materials and Equipment. 8—Visual Education. 9—How to Chose a Text. 10—Trends in the Curriculum. These chapters occupy only 120 pages yet here is a sort of a handbook on that great problem, Principles and Methods.

II—Preparation and Uses of Classroom Materials. Chapter headings: 11—Examples of Student Projects. 12—Collecting, Culturing and Preserving. 13—Laboratory Aids and Substitutes. 14—Preparations for the Microscope. 15—Photosynthesis. 16—Digestion, Nutrition and Growth. 17—Diffusion. 18—Circulation. 19—Respiration. 20—Water Relations of Plants. 21—The Response of Organisms, 22—Reproduction. 23—Heredity. Each of these chapters discusses in good detail the processes and materials needed to illustrate the topic. A very fine contribution in this connection are the suggestions on Laboratory Aids and Substitutes. No new biology teacher need worry about the inability to purchase expensive material, fine substitutes are here suggested. We venture to say that the prospective biology teacher who has used this book in his preparation for teaching will carry it with him when he enters the field of teaching.

A. G. Zander

Adventures with Living Things. A General Biology, by Elsbeth Kroeber, Chairman Department of Biology James Madison High School, New York City and Walter H. Wolff, Chairman Department of Biology and General Science De Witt Clinton High School, New York City and Instructor, School of Education College of the City of New York. Cloth. Pages xiii+798. 14×24 cm. D. C. Heath and Company, New York. 1938. 503 pages with illustrations. Price $1.96.

This is a fairly voluminous high school biology. This text is divided into three parts as follows: I—The Many Living Things of This Earth. This section is a discussion of the phyla of the animal kingdom and the flowering and non-flowering plants. The discussion is entirely descriptive with an introduction on field biology. 140 pages are devoted to this. Part II—How Plants And Animals Live. This division occupies the greater part of the book. It is a very interesting discussion of the life processes of plants and animals including those of the human being. The structures involved in carrying on these life processes are simply discussed so that there would be a minimum of possible confusion due to involved terminology. 386 pages are devoted to this section. Part III—Great Generalizations of Biology. These are listed as follows: There Is Unity On All Living

Things; There is a balance of Life on This Planet; Constant Change is Characteristic of the Earth and Its Inhabitants; The Organism is the Product of its Heredity and Environment Working Together; The Accumulation of Small Changes in Organisms Throughout the Ages Has Produced the Many Types of Today; The Future of Mankind is Rich With Possibilities of Betterment. Each chapter is followed by a list of student activities. This list is long and varied enough so it would cover almost any student's particular case. The book list at the ends of the chapters has apparently been selected with care so that the psychological level of the material coincides with that of the students. There are a few instances where some of the illustrations are misleading. We will just illustrate with one. On page 455 is the picture of a toad carrying eggs on its back. It is called the midwife toad. There is no other reference to it anywhere in the text. On page 60 there is the usual discussion of the life history of the amphibia showing that toads lay their eggs in the water. Really the text might have pointed out that there is a toad which incubates eggs on its back partly but that that toad is found in another part of the world.

A. G. ZANDER

The Relative Merits of Three Methods of Subtraction, by John Theodore Johnson, Teachers College, Columbia University, Contributions to Education, No. 738. Cloth. 76 pages. 14.5×23 cm. 1938. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.60.

The author's specific problem was to determine whether there is any difference in efficiency between the methods of subtraction in whole numbers as used in this country.

During the past 800 years the literature revealed numerous methods, more or less related in many respects. Some authors say that there are three methods of subtraction; others say four, five ,six, seven, and even nine. Some claimed twelve, and one described and illustrated thirty different kinds of whole number subtraction. A discussion of these may be found in Chapters II and III.

This study, however, deals specifically with three methods, here named and very briefly described and illustrated. See the book for a complete discussion.

The Decomposition Method

Example	Think and write
81	7 from 11 = 4
47	4 from 7 = 3
—	
34	

The Equal Additions Method

Example	Think and write
81	7 from 11 = 4
47	5 from 8 = 3
—	
34	

The Austrian Method

Example	Think and write
81	7 and 4 are 11
47	5 and 3 are 8
—	
34	

Tests were prepared for the purpose of determining the relative merits of the above methods. In all, five tests were given to each of more than 1200 pupils. They were so arranged as to test for speed and accuracy and were classified as to content so as to involve not only the basic 100 subtraction facts but also subtraction with four, five, and six place numbers.

Conclusions: (Abbreviated by the reviewer)

1. The decomposition technique is by far the poorest from the standpoint of accuracy and time; 18% more errors and 15% more time than by the equal aditions method; and 16% more errors and 67% more time than by the Austrian method.
2. When errors were held constant so that time was the only variable there was a difference in time of 47% in favor of the equal additions and Austrian methods over the decomposition method.

Note: In the seven previously reviewed experiments, by the author, the results were all in favor of the equal additions method or the Austrian method as against the decomposition method.

Aside from the subtraction issue the dissertation may be more important to some from the fact that it shows a new method of isolating a variable to be measured. This is often difficult in education. See Chapter IV for details of this method.

Those interested in a fuller explanation of the vital problems connected with the teaching of subtraction of whole numbers, as well as a new method of procedure in educational measurement, will find the book a worthwhile contribution to their field of study. All teachers of mathematics and sciences, and those who teach the fundamentals should read and discuss the contents of this book.

JOSEPH J. URBANCEK, *Wilson Junior College, Chicago*

Teaching Arithmetic in the Elementary School, by Robert Lee Morton, Ohio University, Athens, Ohio. Volume I, Primary Grades. Cloth. Pages x+410. 13×20.5 cm. 1937. Price $2.40. Vol. II, Intermediate Grades. Pages xii+538. 1938. Price $2.75. Silver Burdett Company, 45 East 17th Street, New York, N. Y.

These books present a comprehensive treatment of the problems of teaching arithmetic in the primary and intermediate grades. Throughout each book will be found excellent and practical suggestions for teaching the various arithmetical processes.

The books stress the meaning theory of teaching rather than the drill theory. Both volumes summarize the most important findings of research students and use the research as a basis for teaching method.

Book I discusses the following topics:—developing an understanding of number, the place of arithmetic in the curriculum of the primary grades, increasing the child's understanding of number, teaching the fundamental combinations, work in the fundamentals, problem solving, and the course of study

Book II continues a discussion of teaching the fundamental operations and includes fractions, decimal fractions, elements of percentage, denominate numbers, elements of mensuration, and problem solving.

Both books are well written and give a clear cut treatment of teaching procedures in arithmetic. They should find favor with students in pedagogy classes, teachers of methods. superintendents and principals.

CHARLES A. STONE

Elliptic and Hyperelliptic Integrals and Allied Theory, by the Late W. R. Westropp Roberts, Vice-Provost of Trinity College, Dublin. Pages

viii+311. 13.5×14.7 cm. 1938. Cambridge University Press; Macmillan and Company New York, New York.

The present volume is an additional testimony to the thesis that the love for pure mathematics which guides the devotee into the fields of creative research is often found among those who are not professional mathematicians. W. R. Westropp Roberts was a Doctor of Divinity, and at the time of his death was Senior Dean of the College. In the foreword to the book by The Reverend R. R. Hartford, Archbishop King's Professor of Divinity in the University of Dublin we find the following brief sketch of Roberts' mathematical interests.

While a student at the University, Roberts won "most of the important prizes in the Mathematical School . . . graduating with a first class Moderatorship in Mathematics." Between the time he was elected a Junior Fellow (1882) and receiving his Doctor of Divinity (1915) "he contributed a number of papers on various subjects to the Proceedings of the London Mathematical Society and to those of the Royal Irish Academy." During the last twenty years of his life, while engaged in administrative duties, he kept up his interest in the subject to which he had devoted much study, namely, Elliptic and Hyperelliptic Integrals, and had planned to publish a book on the subject. The manuscript of the present volume was given to his publishers, but "unhappily he did not live to revise it or see the work through the press" and it is presented in an incomplete form.

In Chapter I theorems in algebra are treated by means of operational symbols. In Chapter II the general integral $\int \phi(z)dz/\psi(z)\sqrt{A_0 f(z)}$ is studied. Chapter III deals with algebraic equivalents of Abelian transcendents. In Chapters IV–VI the periods and semi-periods of Abelian functions are studied.

It is with a feeling of admiration that the reviewer recommends this work to the students of pure mathematics.

J. S. GEORGES, *Wright Junior College, Chicago*

Introduction to the Theory of Equations, by Louis Weisner, Associate Professor of Mathematics, Hunter College of the City of New York. Pages ix+188. 14×21 cm. 1938. The Macmillan Company, New York. Price, $2.25.

The algebraic theories presented in this volume utilize the concept of a field, thereby enhancing the spirit of algebra and enriching its method. Factorization and properties of a polynomial in a field are treated before considering the solution of equations in the field of rational numbers and in the field of real numbers. The principle of algebraic extensions of a field furnishes a background for the solution by radicals of the general cubic equation and the general quadratic equation. The Fundamental Theorem of Algebra is proved in connection with the concept of algebraically closed field.

Of the nine chapters of the book, the first is devoted to the complex numbers, two to polynomials, two to equations, one to eliminants, resultants and symmetric functions, two to algebraic fields, and the last to constructions by ruler and compasses.

The materials of the text are organized logically, and the presentation is illustrated by means of numerous examples. There is an abundance of well selected exercises. The text is heartily recommended to the teachers and students of the theory of equations.

J. S. GEORGES, *Wright Junior College, Chicago*

Analytic Geometry and Calculus, by Frederick S. Woods and Frederick H. Bailey, Professors Emeriti, The Massachusetts Institute of Technology.

New Edition. Pages xi+524. 14×20.6 cm. 1938. Ginn and Company, Boston, Massachusetts.

The present volume is a new edition of the authors' text published in 1917. The book is a combined treatment of analytic geometry and the calculus, but with an organization of the materials of the two courses into distinct chapters.

To the reader not familiar with the older edition, the following list of chapters may give an idea of the topics treated. Cartesian Coordinates; Graphs of Algebraic Functions; Change of Coordinate Axes; Graphs of Transcendental Functions; The Straight Line; Certain Curves; Parametric Representation; Polar Coordinates; Slopes and Areas; Differentiation of Algebraic Functions; Differentiation of Transcendental Functions; Integration; Applications of Integrations; Space Geometry; Partial Differentiation; Multiple Integrals; Infinite Series; Differential Equations.

J. S. GEORGES, *Wright Junior College, Chicago*

Mathematical Adventures, by Fletcher Durell. 157 pages. Boston, Bruce Humphries, Inc., Publishers. $2.00.

This is a little book that deals with a number of somewhat varied topics on which the author has evidently been meditating for many years. Although there is little that could claim to be new, yet it makes interesting reading for any teacher of mathematics, and even an experienced teacher will pick up points of value in his work. The topics range from a discussion of Co-operative Mathematics to The Fourth Dimension.

WALTER H. CARNAHAN, *Shortridge High School, Indianapolis*

Trigonometry with tables, by Howard K. Hughes, Assistant Professor of Mathematics, Purdue University, and Glen T. Miller, Instructor in Mathematics, Purdue University. Pages viii+189+79. John Wiley and Sons, Inc., New York. Price $2.00.

This is an elementary text in plane and spherical Trigonometry suitable for high school and college. The book is divided into eighteen short chapters which facilitates frequent review and testing and has the advantage of isolating the topics so that some confusion is prevented. The first definitions of the trigonometric functions are given in terms of ordinate, abscissa and distance so that the more general definitions are given before the right triangle definitions. About half of the course is presented before the treatment of logarithms, so that, unless the teacher reverses the order of the text, much of the work must de done with natural functions. The spherical trigonometry is presented in eighteen pages, which would seem to be sufficient where this subject is treated in connection with plane trigonometry. There is an abundance of exercises, many easy and some difficult. Analytic trigonometry is not treated in the early part of the course, but is treated quite extensively in the latter part. DeMoivre's Theorem and its applications are not presented. Answers are provided to part of the exercises. The tables are complete and well set up for use.

WALTER, H. CARNAHAN, *Shortridge High School, Indianapolis*

College Algebra, by Louis J. Rouse, Ph.D., Assistant Professor of Mathematics, University of Michigan. Pages xiii+462. John Wiley and Sons. Inc., New York. Price $2.25.

This is the second edition of the book and many parts have been rewritten, particularly the chapter on determinants and the chapter on progressions. A chapter on probability has been added. Approximately

250 pages treat topics usually given in a good course in high school algebra but the treatment is fuller and the exercises are sufficiently difficult to keep and student interested. The latter part of the text deals with such subjects as Mathematics of Investment, Theory of Equations, Complex Numbers, Horner's Method, Zero and Infinite Roots, Partial Fractions, etc. Explanations are clear and examples are abundant. Answers are provided for part of the exercises.

WALTER H. CARNAHAN, *Shortridge High School, Indianapolis*

Physical Geography and Geology, by L. Dudley Stamp, Sometime Professor of Geology and Geography in the University of Rangoon, Cassel Reader in the University of London. Cloth. Pages viii+526. 1938. Longmans, Green and Company, London. Price $1.75.

This compact volume, filled with a wealth of material and well illustrated with excellent photographs, maps and diagrams would be a valuable addition to the library of every college student of geography. The pages dealing with "The Physiography of the British Isles" furnish material essential to the geographic interpretation of the islands of Great Britain and Ireland.

VILLA B. SMITH

Science in General Education, A Report of the Committee on the Function of Science in General Education, Commission of Secondary School Curriculum, Progressive Education Association. V. T. Thayer, Chairman. Cloth. Pages xiii+591. 14×21.5 cm. 1938. D. Appleton-Century Company, 35 West Thirty-Second Street, New York, Price $3.00.

Here is a book that is certain to have a vital influence in the re-shaping of the secondary science curriculum. Its points of departure from the traditional organization lies in its refusal to consider the various SCIENCES, preferring to deal with SCIENCE as it affects the adolescent and his world. Consistent with all the Progressive Education Association's literature, this work points the way to a more complete integration of all the school's materials.

The book is made up of ten chapters which are grouped into these four major parts:

1. Science Teaching in Relation to General Education.
2. Teaching Science to Meet the Needs of Adolescents in the Basic Aspects of Living.
3. Understanding the Student and Evaluating His Growth.
4. Using This Report as a Basis for Planning the Science Program.

All persons concerned with curriculum revision should study this searching report. College courses in the teaching of science will use it both as an interpretation of the new view of science teaching objectives and as a rich source of concrete types of methods. The teacher in service will find its generalizations highly stimulating and will adapt many of the carefully outlined specific devices to his own teaching situation. The many pages devoted to an up-to-date descriptive bibliography and to learning materials and their sources are unusually valuable.

DEWARD DOUB, *Marquette School, South Bend, Indiana*

Science Problems for the Junior High School, by Wilbur Beauchamp, John C. Mayfield, and Joe Young West. Book One. Cloth. Pages 432. 1938. Scott, Foresman, and Company, 623 South Wabash Avenue, Chicago, Ill. Price $1.28.

Some one has recently criticized a science program that would teach the scientific attitude simply by not teaching biology. In the first para-

graph of the foreword addressed "to the student" the authors of this text say, "—the way you go about your work in science is more important than what you learn."

However, one cannot accuse the writers of generalizing nor of not being specific. To the reviewer the thing that prevents this from being just another text is the fact that so little material is attempted and that that material is developed so fully. The problem method is maintained consistently as is indicated by the titles of the eleven challenging Chapters:

1. How do Scientists Make Discoveries?
2. What Kind of World do you Live in?
3. What is a Material?
4. How do Heating and Cooling Change Materials?
5. How can one Kind of Substance Change into Another Kind?
6. How do we Use and Control Fire?
7. How do Magnets Work?
8. How are Plants and Animals Alike?
9. How do Plants and Animals get Food?
10. Why do we Eat Different Kinds of Food?
11. How do Plants and Animals Live Together?

Each of these units is broken up into three, four, or five problems. The directions to the student are so complete that the keeping of a notebook should be both easy and interesting. No workbook would seem necessary. The choice and number of illustrations are admirable.

DEWARD DOUB, *Marquette School, South Bend, Indiana*

An Introduction to Laboratory Technique, by A. J. Ansley, Physics Department, University College of the South-West of England, Exeter. Cloth. Pages xiii+313. 13.5×22 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.50.

Skill in laboratory technique is a great asset to the science teacher but the training years are so crowded with theoretical courses that few students have time to develop skill in many phases of technical work. This book was planned to fill the gap by providing the essential directions for doing many of the necessary odd jobs connected with laboratory work. It was written primarily for the physics student and teacher but many of the topics treated apply to the other sciences also. An excellent chapter on the general care and repair of apparatus and furniture is followed by chapters on Cement, Lutes and Solvents, Electrical Measuring and Indicating Instruments, Electric Motors, Electroplating, Glass-Blowing and Glass-Working, Graduation of Apparatus, Insulators and Their Working, Mercury and Its Purification, Optical Projection of Lantern Slides, Production of Mirror Surfaces, Soldering of Metals, Storage Cells. The Appendix gives directions for first aid treatment and several well selected tables.

The subject matter is reliable and the directions are clear. Many drawings and half tones support the descriptive matter. It is avaluable book for every shop and laboratory.

G. W. W.

Physics, A Textbook for Colleges. by Oscar M. Stewart, Professor of Physics, University of Missouri, Columbia, Missouri. Third Edition. Cloth. Pages x+750. 15×23.5 cm. 1939. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $4.00.

This text will appeal especially to teachers and students of physics in the liberal arts colleges. There is a growing tendency toward arranging

the subject matter in order of increasing difficulty rather than in the logical order. Professor Stewart has recognized the advantage gained by starting students off with the easier parts of mechanics and postponing the more difficult topics until some experience in the mastery of a new type of study has been acquired. All the way through the text student difficulties are kept in mind. The discussions are clear and simple, difficult concepts are introduced by means of daily life applications, and all explanations of principles are reinforced by many well graded numerical problems.

The text has now been completely modernized by introduction of recent developments in atomic and nuclear physics. Sufficient discussion of the new ideas of atomic structure is introduced early in the text to enable the student to think of energy transformations in the light of modern evidence. The mks system of units is carried along parallel with the cgs system. Teachers who are seeking a text suited to the needs of that large body of students who enter physics with the most meager mathematical preparation and outlook will find this text admirably suited to their demands. However, it is not in any sense just a soft course; it contains all the material normally covered in general physics and will give ample preparation for the specialized courses to follow for science majors.

G. W. W.

MOTION PICTURE REVIEWS

A Trip to the Sky. Distributed by Walter O. Gutlohn, 35 West 45th St., New York City; Ideal Pictures Corp., 28 East 8th Street, Chicago, Ill.; Cinema, Inc., 234 Clarendon Street, Boston, Mass. 16 mm., silent or sound. Rental price: silent, $2.50, sound $3.50. The sound version is the one reviewed.

I. The Story of the Film.

The film opens rather impressionistically with "shots" of the sea and quickly passes to actual views of a telescope in use. We are informed that it is through the use of instruments such as this that we have learned that the earth is not the center of the solar system.

Then come the scenes which, from the purely instructional angle are among the best in the film—the use of parallax to measure distance, the use of simple triangulation to measure the distance from the earth to the moon.

It is at this point that we begin the trip which gives the name to the film. We arrive on a dead moon. We are told of the unbearable heat of the side of the moon that faces the sun. We then proceed to Mars, noting the change in what appears to be vegetation and hence deduce the existence of seasons on the planet. Then Saturn, with its majestic ring appears. As we proceed at transcendent speeds, we pass other objects in the universe—nebulous gas and star clusters, and finally reach the confines of the universe.

II. Criticism of the Film as a Teaching Aid.

The reviewing committee were united in their opinion that this film might have considerable value in stimulating interest and giving certain appreciations. For these purposes the film has actually been used with elementary school children with favorable results. By the same token the film would not be of much value in imparting accurate information about the universe or in suggesting how that information is obtained. An exception to this latter statement may be allowed for the work on the measurement of distances which is quite well, although somewhat too briefly, described.

Unfortunately the film is guilty of two bad defects. First, many of its statements are not accurate. The earth is referred to as a "sun." The surface of Saturn is portrayed as covered with boiling lava. The statement is made that probably many stars have planetary systems like that of our sun. Furthermore, though not completely explicit on this point, the film at least implies an origin of the solar system in accordance with the discredited nebular hypothesis. The second bad defect lies in the lack of clarity as to just where we are supposed to be when the various scenes are viewed. We hop back and forth in the universe with truly bewildering rapidity.

The reviewing group was in general agreement as to the probable interest that students would have in the film and in its unique value in stimulating interest, since most astronomical films are too greatly concerned with imparting the utmost of information. They felt, however, that the film attempts to cover too much ground and that the use of the film would have to be circumscribed about with the most meticulous care, lest erroneous impressions result.

III. Technical Qualities of the Film.

Artistically the photography of the film is good, many of the shots, which must have been made in miniature, having the beauty of actual scenes. However, the French producers of this film have not managed the musical background at all well. Throughout most of the film the musical background is little more than a rumble and sometimes, at least in the film that we heard, sounds off pitch. The words of the commentator were generally intelligible, although in another showing of the film, seen by seme of the reviewing group, the speech was quite difficult to understand. Whether this indicates a lack of uniformity in the prints of this film (the same machine was used for both showings) cannot be stated for certainty.

IV. Rating.

Age level: Because of the character of the film—at all levels.

Quality of photography: Good

Selection of scenes: Poor, because of the difficulty in determining the locale.

Quality of narration: Fair as to intelligibility; poor as to accuracy.

Living Jewels. Distributed by Walter O. Gutlohn, 35 West 45th Street, New York City; Ideal Pictures Corp., 28 E. 8th St., Chicago, Ill.; Cinema, Inc., 234 Clarendon St., Boston, Mass. 1 reel 16 mm., sound. Rent. $1.50.

I. The Story of the Film.

The film brings to life organisms which pupils seldom have more than an opportunity to read about or to examine as models. The feeding habits and protective adaptations of the flower-like sea-anemone are illustrated by remarkably clear photography. A small fish becomes entangled in the many tentacles and is slowly folded in with them. Later the tentacles again blossom forth. Sea fans and various forms of coral are shown in large clusters. Living individuals within the colonies are shown much enlarged. Various other striking forms of the coelenterates and helminths are shown in their natural environments.

II. Criticism of the Film as a Teaching Aid.

Living Jewels was originally photographed and prepared for commercial use—as a short subject. It has since been adapted to classroom use. The primary purpose still seems to be to entertain or interest rather than to

instruct. The material is not organized to present any particular unified concept other than the beauty of a variety of sea forms. The film may be used for motivation purposes on practically any grade level. It is probably of most use in high school biology classes.

III. Technical Qualities of the Film.

The photography is of a quality rarely excelled. The shots are both well defined and artistic. Enlarged views of individual coral organisms and of the internal activities of organisms are particularly effective. The sound track is rather poor for teaching purposes. The narrator's words are frequently difficult to distinguish—the names of several species are not clear. It is doubtful if the musical background is of value. Many teachers will probably prefer to run the film silent, furnishing their own comments.

IV. Rating.

Age level: Of interest to all levels from upper elementary.

Quality of photography: Excellent.

Selection of scenes: From artistic standpoint excellent; for science content fair.

Quality of narration: Speech only fair; music probably harmless.

Reviewing Committee
N. Eldred Bingham
F. T. Howard
F. M. Worrell
Rose Wyler
Herbert Zim
H. Emmett Brown, *Chairman*